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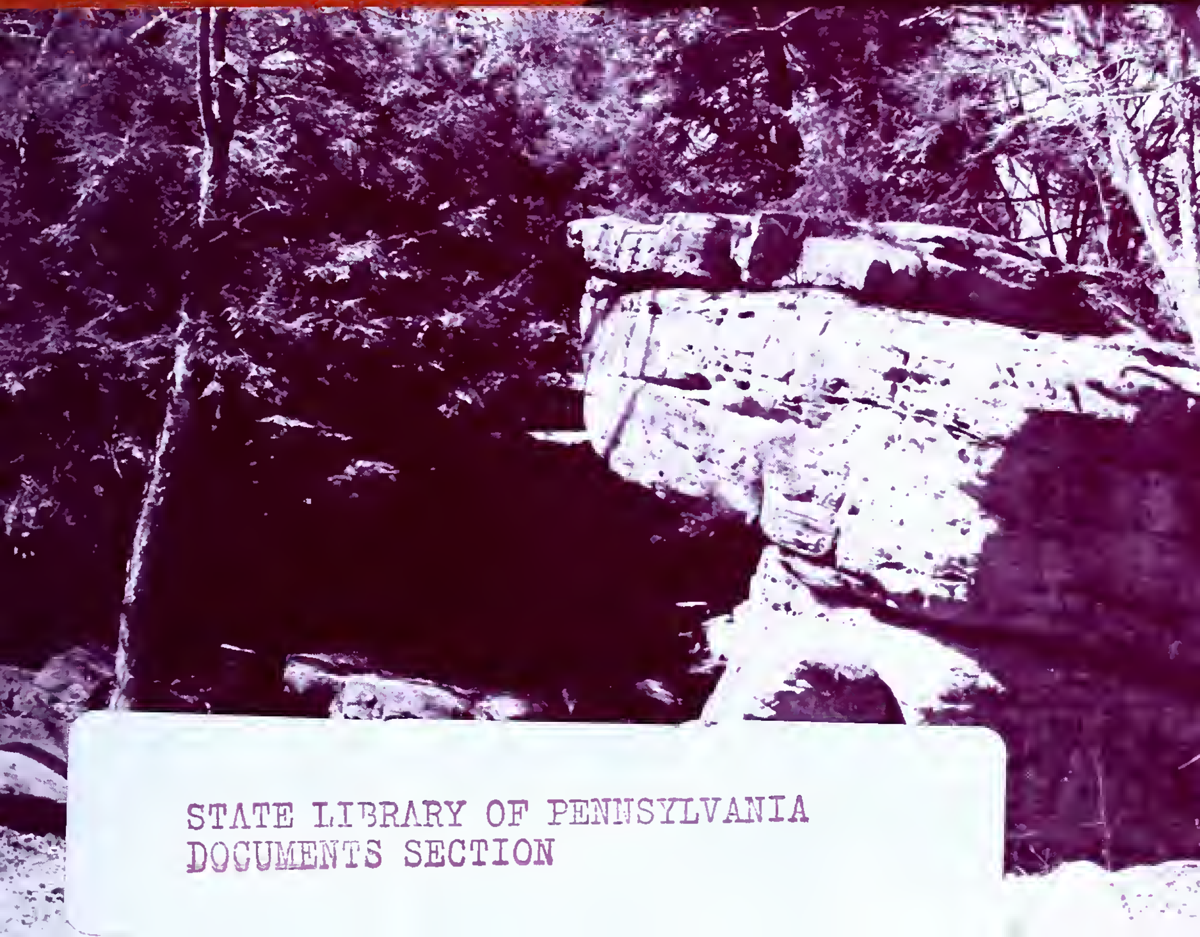
PENNSYLVANIA GEOLOGY



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TOPOGRAPHIC AND GEOLOGICAL SURVEY
Arthur A. Socolow, State Geologist

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ON THE COVER: Bilger Rocks, on Pike Township Route 203, 4 miles northwest of Curwensville, Clearfield County. Huge blocks of cross-bedded Homewood Sandstone, bounded by joint separations form a "rock city."

PENNSYLVANIA GEOLOGY is published bimonthly by the Topographic and Geologic Survey, Pennsylvania Dept. of Environmental Resources, Harrisburg, Pennsylvania, 17120.

Editor, Arthur A. Socolow; Associate Editor, Donald M. Hoskins.

Articles may be reprinted from this magazine if credit is given to the Topographic and Geologic Survey.

February 1983

FROM THE DESK
OF THE
STATE GEOLOGIST . . .

GEOLOGIC SERVICES CONTINUE THROUGH GOOD TIMES OR BAD

The minerals industry, as the basic source of raw materials for our nation's industrial sector, is one of the major victims in times of a depressed economy. Thus it is that Pennsylvania's production of industrial and construction minerals has sagged in the past year, as has exploration for new reserves of those minerals.

Yet we at the state's Geological Survey find that the number of incoming requests for geologic services and information remains high, even increasing in certain subject areas. Questions from individuals, municipalities, and industry concerning groundwater and water well locations have increased, probably a result of recent drought episodes and the recognition that water management is a growing necessity in eastern United States.

Our geologic services to the recreational community show up in the calls which come to us concerning mineral and fossil collecting sites, scenic geologic trails and outstanding geologic features, accessible caves, and availability of our topographic maps for hunting, fishing, and camping activities.

The public has begun to recognize our role and assistance in matters of geologic hazards, such as sink hole problems in eastern Pennsylvania, landslides in western Pennsylvania, bluff failures (Lake Erie), mine subsidence, flood-prone areas, and even earthquake potential. Our geologic data and knowledge of the processes involved serve not only to implement corrective actions after the fact, but also help to initiate preventive measures in hazard-prone areas.

As more and more communities and individuals recognize the need for both cleaning up existing sites as well as operating new waste disposal sites, we find increasing questions coming to us concerning the identification of favorable and unfavorable geologic conditions affecting such sites, involving both solid wastes and liquid wastes.

Construction activities, although considerably reduced, still result in geologic service needs relating to foundation conditions under bridges and dams, availability of appropriate nearby building stone and construction aggregates, and location of least difficult (and least costly) geologic routes for new pipelines, transmission lines, phone lines, and roadways.

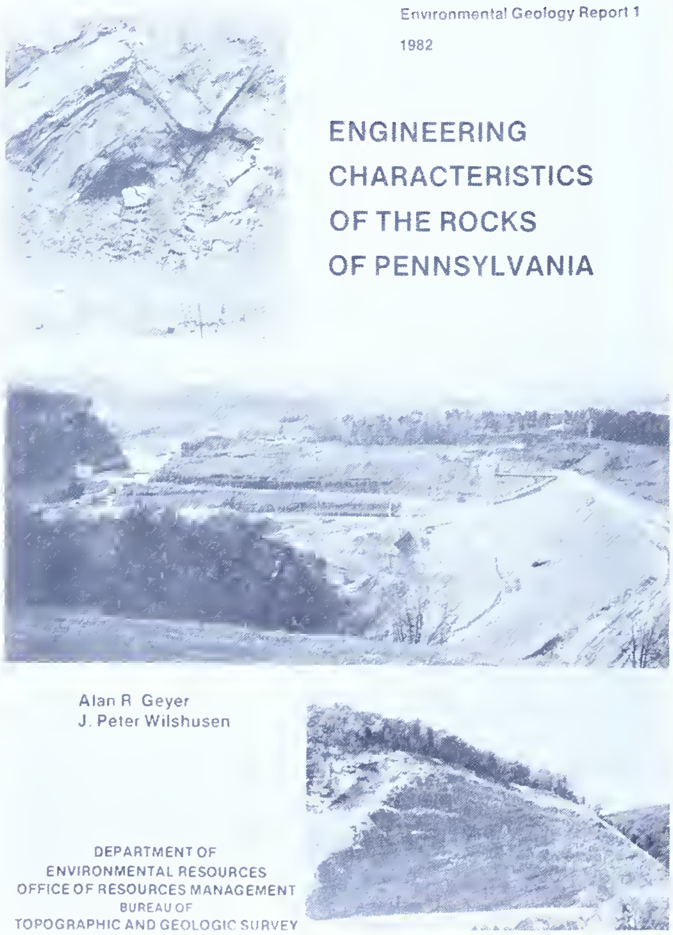
Even as the activity of the coal and metals exploration industry has decreased somewhat, conversely exploration and development of Pennsylvania's natural gas and oil has markedly increased, resulting in a wide range of requests for geologic information and services, from regional geologic maps and cross sections, to discussions of site specific data and well samples on file here for all to utilize.

The Pennsylvania Geological Survey is pleased to be carrying out its mandate to serve the geologic needs of the public and extends a standing invitation to one and all to utilize our geologic data and expertise. We welcome phone calls to the main office in Harrisburg (717) 787-2169 or our branch office in Pittsburgh (412) 565-5030, and we invite inquiries by mail or personal visit to these offices at 914 Executive House, 101 S. Second Street, Harrisburg, PA 17101 or 1201 Kossman Bldg., 100 Forbes Avenue, Pittsburgh, PA 15222.

Arthur A. Socolow

CHARACTERISTICS OF PENNSYLVANIA'S ROCK FORMATIONS

A new Pennsylvania Geological Survey publication which describes the practical, engineering and construction characteristics of bedrock formations in the state, has recently been published and released. This is a completely revised second edition, especially prepared to accompany the revised 1980 State Geologic Map. The book contains 300 pages of information useful to anyone dealing


Environmental Geology Report 1
1982

ENGINEERING
CHARACTERISTICS
OF THE ROCKS
OF PENNSYLVANIA

Alan R. Geyer
J. Peter Wilshusen

DEPARTMENT OF
ENVIRONMENTAL RESOURCES
OFFICE OF RESOURCES MANAGEMENT
BUREAU OF
TOPOGRAPHIC AND GEOLOGIC SURVEY

Photo of the cover of Environmental Geology Report 1 with one or more of the 210 geologic rock units in Pennsylvania as shown on the state geologic map.

With introductory material describing major engineering characteristics of the rocks of Pennsylvania, each geologic unit (a group, formation or member) is enumerated, outlining the lithology, bedding, fracturing, and weathering characteristics, topographic expression, drainage conditions, porosity and permeability, groundwater potential, ease of excavation, cut-slope stability, foundation stability and availability as potential constrution material. Laboratory Rock Test Data on representative samples is provided where available for some formations. Photographs accompany the descriptions of most rock units to provide visual impressions of the rock units listed.

Engineering Characteristics of the Rocks of Pennsylvania, Environmental Geology Report 1, Second Edition, Revised, 1982, by Alan R. Geyer and J. Peter Wilshusen is available from the Pennsylvania State Book Store, P.O. Box 1365, Harrisburg, PA 17125. The mail order price is $3.90 (plus 6% sales tax for Pennsylvania residents). Check made payable to the Commonwealth of Pennsylvania must accompany the order.

Bless our students

From a transplanted Pennsylvanian, Professor Don Groff at Western Connecticut State College, come these "gems":

"The theory of evolution was greatly objected to because it made men think."

"Charles Darwin was a naturalist who wrote the Organ of the Spices."

"The Earth makes a resolution every twenty-four hours."

"The moon is a planet just like the Earth, only deader."

CORRECTION

The price listed for Map 1, "Geologic Map of Pennsylvania" in the December, 1982 issue of Pennsylvania Geology is incorrect. The correct price is $11.50 plus 6% sales tax for Pa. residents.

BARITE IN THE DEVONIAN MARCELLUS FORMATION, MONTOUR COUNTY

by John H. Way and Robert C. Smith
Pennsylvania Geological Survey

Barite nodules and trace sphalerite have recently been discovered within a Devonian marine sequence of limy black shales in the north-central portion of the Valley and Ridge province in Montour County. The 16+ ft. thick series of interbedded, dark, fissile mudstones and massive limestones occurs in the Marcellus Formation in the Washingtonville 7½′ quadrangle. This interval is thought to be equivalent to the Purcell limestone, an informal member of the Marcellus, reported in the subsurface of central and southwestern Pennsylvania (Cate, 1963, p. 232). This occurrence was identified during aerial mapping for the forthcoming Pennsylvania Geological Survey Atlas report A154cd involving the Washingtonville and Millville quadrangles.

The mineralized exposure (41°04′44″N/76°40′22″W), on the property of the P. E. Wemple family, is located just northwest of Pennsylvania Power and Light Company's Montour Steam Electric Station in Derry Township, approximately 2 mi. north of Washingtonville and 9 mi. north-northwest of Danville. At this locality, three distinct limestone beds form resistant ledges within the stream-cut, northwestern bank of Chillisquaque Creek and across the creek bed itself.

Mineralogy

Several varieties of nodules, ranging from 1.5 to 8 in. in diameter, weather out of the fissile mudstone and accumulate on the bank and in the creek bed. Although the composition of the different varieties of nodules tends to overlap, four types were recognized: (1) barite rich: very dense, dark gray to black nodules (Figure 1) composed of concentric layers of radiating barite, along with varying amounts of pyrite; also some disseminated, yellowish-gray sphalerite and trace chalcopyrite can be observed; primarily from the middle portion of the zone; (2) pyrite rich: usually smaller, often

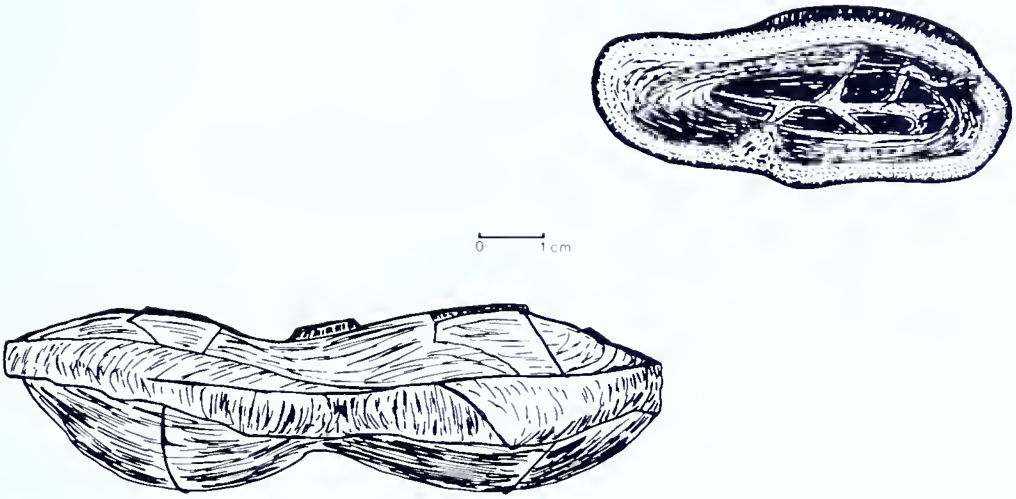
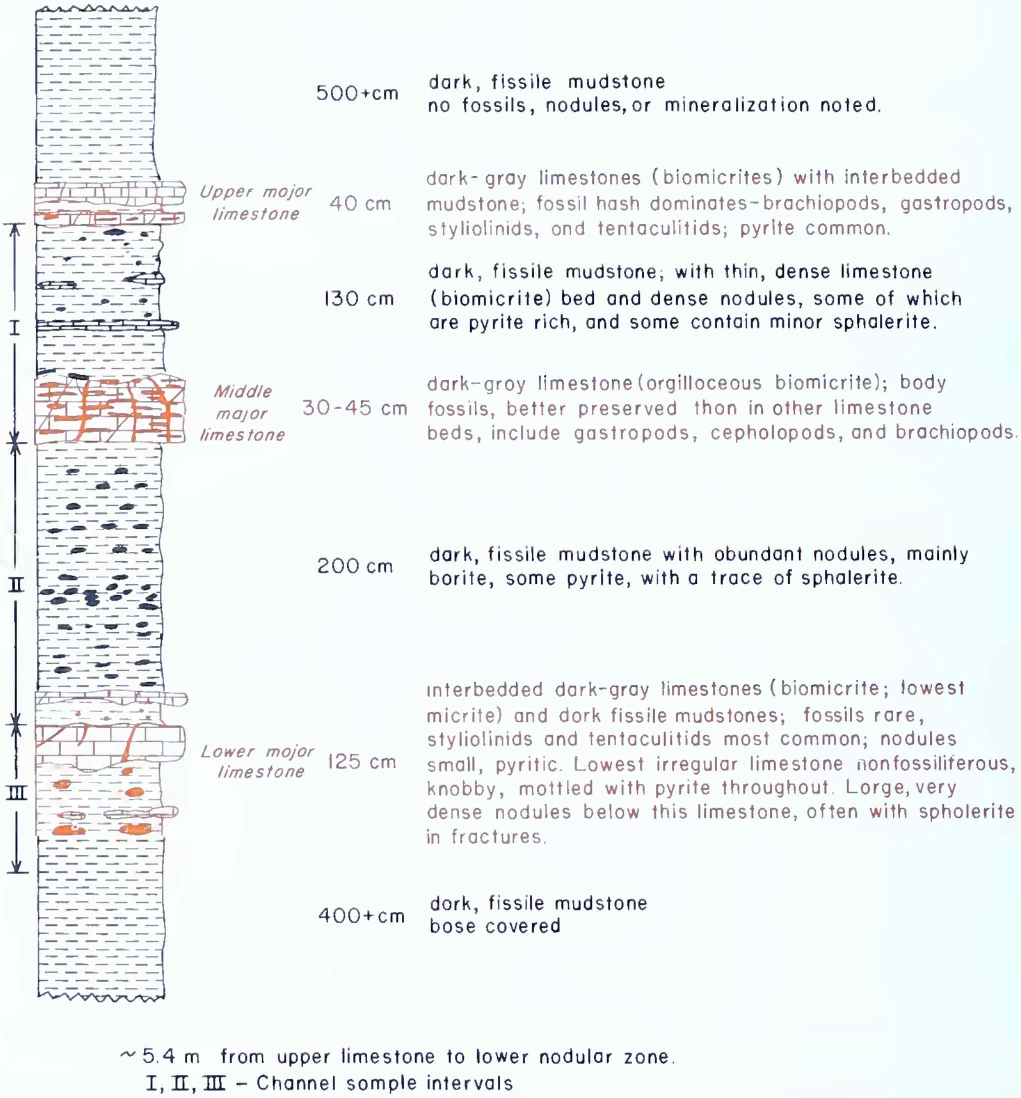


Figure 1. Sketch of complete and broken barite-rich nodules from the Washingtonville barite locality, Montour County. The fractures in the core of the nodule are usually filled with coarse, crystalline, clear barite in contrast to the darker, fine-grained barite matrix. Pyrite forms distinct bands toward the outer rim of the nodules as well as being disseminated throughout the barite matrix.

highly weathered, and most common in the upper and lower zones; (3) slightly mineralized: large, very tough nodules, having a small amount of barite and/or sphalerite in thin fracture fillings, usually with the sulfides toward the outer rims; concentrated in a zone below the lowest limestone; (4) unmineralized: very tough nodules composed primarily of very fine grained calcite and quartz, a small amount of pyrite, and possibly muscovite and chamosite, occurring throughout the mineralized interval. Figure 2 is a columnar section of this interval. Barite-rich nodules are concentrated between the lowest and middle major limestones and the large nodules containing sphalerite in fracture fillings occur below the lowest major limestone.

Three true channel samples I, II, III, (Figure 2) were cut through this section and results of the analyses are summarized in Table 1. Based on X-ray diffraction scans, the bulk rock consists of major amounts of quartz and calcite, minor muscovite and feldspar such as albite, and trace barite, pyrite, and a chlorite such as chamosite. Comparison with similar mineral mixtures containing known amounts of barite suggests that sample I contains about 1.5% barite, II contains about 0.6% barite, and III contains less than or equal to 0.2% barite.



dark, fissile mudstone
no fossils, nodules, or mineralization noted.

dark-gray limestones (biomicrites) with interbedded mudstone; fossil hash dominates-brachiopods, gastropods, styliolinids, and tentaculitids; pyrite common.

dark, fissile mudstone; with thin, dense limestone (biomicrite) bed and dense nodules, some of which are pyrite rich, and some contain minor sphalerite.

dark-gray limestone (argillaceous biomicrite); body fossils, better preserved than in other limestone beds, include gastropods, cephalopods, and brachiopods.

dark, fissile mudstone with abundant nodules, mainly barite, some pyrite, with a trace of sphalerite.

interbedded dark-gray limestones (biomicrite; lowest micrite) and dark fissile mudstones; fossils rare, styliolinids and tentaculitids most common; nodules small, pyritic. Lowest irregular limestone nonfossiliferous, knobby, mottled with pyrite throughout. Large, very dense nodules below this limestone, often with sphalerite in fractures.

dark, fissile mudstone
base covered

~5.4 m from upper limestone to lower nodular zone.
I, II, III – Channel sample intervals

Figure 2. Stratigraphy of the Washingtonville barite locality.

X-ray fluorescence scans verify that barium is strongly enriched in the relative amounts indicated above, and that zinc and copper are slightly enriched relative to most black shales. These scans and commercial, semiquantitative emission spectographic analyses suggest that other elements such as silver, arsenic, molybdenum, lead, and vanadium, that are enriched in other black shale units, are not anomalous at this locality.

The verification of barite from the stratigraphically lower Tioga Ash Bed in Perry and Northumberland counties suggests that volcanically derived barium may have been introduced into a restricted marine environment such as is represented at this locality. Paleontologic evidence and the absence of other heavy metals, however, tends to rule out a deep, euxinic (oxygen-depleted) environment.

Stratigraphy

Although the dark, fissile mudstones within this interval appear similar to exposures in the typical Marcellus Formation observed in nearby outcrops and adjacent quadrangles, the limestones are unique and have not been reported from adjacent quadrangles. Calcareous (siderite?) concretions and very fine grained limestone nodules had been reported as occurring within the Marcellus Formation, but barite and sphalerite have not.

The limestones in this interval vary in appearance and composition from very dense biomicrites to more argillaceous biomicrites. The fossils, which for the most part are fragmentary, are dominated by styliolinids and tentaculitids, ostracodes, brachiopods, trilobites, and gastropods. This fauna is similar to that reported by Rickard (1952) from the Cherry Valley limestone, a member of the

Table 1. Semiquantitative estimates of the percent barite and the mineralogy of continuous channel samples through the mineralized zone from top to bottom.

Sample	Thickness & Lithology	% Barite [1]	Minerals Major	Minor	Trace
I	1.25 m dark mudstone 0.5 m dark limestone	1.5	calcite, quartz	feldspar (such as albite), dolomite	muscovite (such as 1 M and 2 M_1), barite, pyrite (?), chlorite (such as chamosite)
II	1.85 m dark mudstone	0.6	quartz, calcite	muscovite (such as 1 M and 2 M_1), feldspar (such as ablite), chlorite (such as chamosite)	barite, pyrite (?)
III	0.5 m dark mudstone 0.4 m dark limestone	0.2?	quartz, calcite	muscovite (such as 1 M and 2 M_1), feldspar (such as albite)	barite (?)

(1)% Barite represents an estimate by X-ray powder diffraction which compares the 3.10 Å barite spacing with known mixtures of pure minerals; relative amounts partially verified by X-ray fluorescence and semiquantitative emission spectrography.

Marcellus Formation in eastern New York state. A fragment from a large cephalopod, *Agoniatites vanuxemi* var. *nodiferus* (Hall), estimated to have been at least 26 cm (10 in) in diameter, was collected from a float block, presumably from the middle major limestone. *A. vanuxemi* is reportedly confined to a thin interval occurring below the base of the Cherry Valley limestone at its type section, and to a thin limestone within the Cherry Valley further to the southeast (Rickard, 1952, Fig. 2). While the lithologic descriptions of the Cherry Valley limestones themselves do not appear to be similar to the limestones here, the presence of pyrite nodules found abundantly in the lower layers of this unit (Rickard, 1952, p. 512), the presence of similar fauna including *A. vanuxemi*, and the position stratigraphically within the Marcellus Formation would suggest some basis for the correlation of this interval with the Cherry Valley.

In the subsurface of southwestern Pennsylvania, the Marcellus Formation grades from calcareous shales in the west to dark, silty or carbonaceous shales containing thin limestone units in the basal portions in the east (Cate, 1963, p. 232). These basal limestones were seen to have utility as subsurface markers and Cate (1963, p. 232) informally named a particular unit in the A. Morris No. 1 well, drilled in the Purcell gas field in Bedford County, the Purcell limestone.

The Purcell occurs as concretionary to lenticular limestone beds and is generally sparsely fossiliferous. Dennison, Hoskins, Hasson, and de Witt have reported this unit from Marcellus exposures throughout the central Appalachians and it is thought to be a good time marker because of its regular stratigraphic position about the Tioga Ash Bed, a thin zone comprising several layers of tuff and tuffaceous shales representing an extensive volcanic ash deposit. Based on subsurface work in Pennsylvania and New York both Cate and Dennison have suggested that the Purcell limestone in Pennsylvania is equivalent to the Cherry Valley limestone in New York (Dennison and others, 1972, p. 56).

If, in fact, the Purcell and Cherry Valley limestones are correlatable, it is suggested here that the barite-rich limestone sequence near Washingtonville is equivalent to this interval. These beds may also correlate with the Selinsgrove upper limestone (White, 1883, p. 79) at Selinsgrove Junction, Northumberland County, and limestones noted by Faill and others (1978, p. 9) west of Sunbury and near Shadle, Snyder County.

Barite nodules as well as barite and sulfide mineralization within nodules have been noted in several other localities within the Washingtonville quadrangle, adjacent quadrangles, and at a similar stratigraphic horizon in other portions of the folded belt. W. de Witt, Jr. has collected barite nodules from Bedford County and noted sphalerite in barite nodules from the Lock Haven area (personal comm. 10/82). Distinctive "golf balls with a radiating interior structure" have been reported by Dennison and others (1972, p. 56) from this horizon, suggesting the possibility that this mineralization may persist into Maryland, West Virginia, and Virginia as well.

Based on knowledge of other nodular barite occurrences in the Marcellus, the presence of base-metal sulfides at this locality, and our verification of barite in the Tioga Ash Bed, the Devonian marine section appears to be an attractive exploration target for bedded-barite deposits.* Anomalous barium contents of stream sediments from this portion of the 1° x 2° Williamsport quadrangle (Cook, 1981), suggest that the Washingtonville 7½′ quadrangle would be a good place to start.

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* D. A. Brobst, economic geologist formerly with the U.S.G.S., pointed out that in Nevada such nodular barite is peripheral to the more massively bedded barite, and, in places, is peripheral to massive sulfide ore deposits such as at Rammelsberg and Meggen in West Germany (1980, oral communication to A. V. Heyl, U.S.G.S.).

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SURVEY ANNOUNCEMENTS

COAL RESOURCE REPORT FOR NORTHEASTERN GREENE COUNTY

A new report, *"The Economic Geology of the Upper Freeport Coal in Northeastern Greene County, Pennsylvania"* has been published by the Bureau of Topographic and Geologic Survey, Department of Environmental Resources.

The report, written by staff geologist Viktoras W. Skema and former staff geologists Mark A. Sholes and William E. Edmunds, provides information concerning the important characteristics of the Upper Freeport coal and its distribution in the Waynesburg and Mather area of Greene County. In addition to giving a detailed description of the coal, the publication attempts to reconstruct the setting in which the coal was deposited, so that patterns of its distribution and internal characteristics can be better understood. With this approach, a more accurate prediction can be made of the coal's nature and location in adjacent unexplored areas.

The 51 page publication contains 21 figures and a table of coal resource estimates. Included among the figures are: (1) stratigraphic cross sections showing the position of the Upper Freeport coal in relationship to key beds in the overlying Glenshaw Formation; (2) detailed cross sections of the coal with non-coal partings and character of the immediate roof rock indicated; (3) various maps showing thickness, distribution, and ash and sulfur content of the coal; (4) maps showing composition, thickness and distribution of rock units both above and below the coal; and (5) maps interpreting environments of deposition during and after development of the coal-forming peat.

The publication is designated as Mineral Resource Report 76 and may be obtained from the Pennsylvania State Book Store, P.O. Box 1365, Harrisburg, PA 17125. The mail order price is $3.00 (plus 6% sales tax for Pennsylvania residents). Check payable to Commonwealth of Pennsylvania must accompany order.

NEW REPORT HIGHLIGHTS INCREASED OIL AND GAS ACTIVITY

Oil production in Pennsylvania rose 27 percent in 1981 over the prior year and gas production rose 26 percent according to figures released in the Pennsylvania Geological Survey's new report *"Oil* *and Gas Developments in Pennsylvania in 1981."* Oil production for the year totalled 3,729,214 barrels, and equally important, Pennsylvania oil reserves increased to 50,946,000 barrels. At prices ranging from $38.00 to $35.00 per barrel, Pennsylvania's oil production had a crude oil value of well over $100 million.

Gas production in the state in 1981 amounted to 97.4 billion cubic feet and the gas reserves increased 7 percent to 2316 billion cubic feet. While the price paid for the gas varied widely, the total value of the gas produced during the year was on the order of $200 million.

The total number of oil and gas wells drilled in Pennsylvania in 1981 was 3,554, a 76 percent increase over the prior year. The most active oil well drilling was in Warren, Venango, and McKean Counties, while the most active gas well drilling was in Indiana, Crawford, Erie, Jefferson, and Clearfield Counties.

Details of these and all other oil and gas development and exploration activity are presented in the Pennsylvania Geological Survey's Progress Report 195, "Oil and Gas Developments in Pennsylvania in 1981." This 116 page report complete with tables and maps, was compiled by staff petroleum geologist Dr. John A. Harper. The report may be ordered by mail from the Pennsylvania State Book Store, P.O. Box 1365, Harrisburg, Pennsylvania 17125. The mail order price is $2.50 (plus 6% sales tax for Pennsylvania residents). Check payable to the Commonwealth of Pennsylvania should accompany the order.

BLOOMSBURG-MIFFLINVILLE GEOLOGIC ATLAS

A detailed atlas on the geology and mineral resources of the Bloomsburg and Mifflinville quadrangles and northwest corner of the Catawissa quadrangle, Columbia County, has been issued by the Pennsylvania Geological Survey. Authored by staff geologist Dr. Jon D. Inners, the report consists of a well-illustrated 152-page text accompanied by a full-color bedrock geologic map (with four cross-sections) and a full-color surficial material map. Special attention is devoted to the economically-important sand and gravel resources in the Susquehanna River and Fishing Creek valleys, as well as the influence of geology on problems of cut-slope stability, excavation difficulty, foundation stability, and flooding. The text includes detailed discussions of the stratigraphy, structural geology, environmental and engineering geology, and mineral resources of the area.

The Bloomsburg-Mifflinville area lies within a glaciated portion of the Valley and Ridge topographic province. Bedrock units range from the Middle Silurian Rose Hill Formation to the Upper Mississippian Mauch Chunk Formation. Important geologic structures include the Berwick anticlinorium, Lackawanna synclinorium, and Light Street thrust fault. The surficial units include Illinoian and Wisconsinan glacial and glaciofluvial deposits, windblown silt (Nescopeck Loess), and various types of colluvium and alluvium. Late Wisconsinan glacial-border deposits occur in the northeast corner of the Mifflinville quadrangle.

Anyone dealing with geologic, hydrologic, foundation engineering, and land-use problems in central Columbia County or nearby areas will find this report of considerable interest and benefit.

Atlas 164cd, *"Geology and Mineral Resources of the Bloomsburg and Mifflinville quadrangles and part of the Catawissa Quadrangle, Columbia County, Pennsylvania,"* is available by mail from the State Book Store, P.O. Box 1365, Harrisburg, PA 17125, at a cost of $17.40 (add 6% sales tax if mailed to a Pennsylvania address). Check made payable to the Commonwealth of Pennsylvania must accompany order.

Estimates of Undiscovered Oil and Gas in the United States

A new USGS publication has been released, entitled "Estimates of Undiscovered Recoverable Conventional Resources of Oil and Gas in the United States."

Authored by G. L. Dolton and others, the latest USGS estimates of United States Conventional Oil and Gas Resources are presented for the Nation as a whole, and for 137 provinces, 15 regions, onshore areas, offshore areas, continental shelf, continental slope, Alaska, and the lower 48 states. Methodology for resource appraisal is outlined; comparison with other recent estimates is included.

For the Nation as a whole, the undiscovered recoverable conventional oil resources are estimated to range from 64.3 to 105.1 billion barrels with a mean estimate of 82.6 billion barrels; gas resources are estimated to range from 474.6 to 739.3 trillion feet with a mean estimate of 593.8 trillion feet.

Reserve figures for Pennsylvania are included in the appalachian Region statistics. For the Appalachian Region the undiscovered recoverable conventional oil resources are estimated to range from 0.1 to 1.5 billion barrels with a mean estimate of 0.6 billion barrels. Gas resources are estimated to range from 6.4 to 45.8 trillion feet with a mean estimate of 20.1 trillion feet.

USGS Circular 860 is free and available from: Eastern Distribution Branch, U.S. Geological Survey, 604 South Pickett Street, Alexandria, Virginia 22304.

SILICA AS PURE AS THE DRIVEN SNOW? NOT YET, BUT WE'RE GETTING CLOSER!

by R. C. Smith II, and
S. W. Berkheiser, Jr.
Pennsylvania Geologic Survey

A composite sample of about 50 ft of Tuscarora Formation sandstone from Tuscarora Mountain, Franklin County, was found to contain only 0.06% Fe_2O_3 and 0.30% Al_2O_3. A favorable low dip, negligible overburden, and good roads suggest that the area warrants investigation by the silica industry in central Pennsylvania. Acid beneficiation reduced the Al_2O_3 to 0.06%.

The sampled site (latitude 39°57′02″N and longitude 77°56′13″W) is a natural outcrop located at an elevation of about 2,400 ft on the east-facing slope of the portion of Tuscarora Mountain known as Big Mountain. The outcrop is about 150 ft east of a former fire tower and overlooks Path Valley. The outcrop is in Buchanan State Forest, 3.0 mi northwest of Fort Loudon, Metal Township, Franklin County. It is easily reached from the east or west by U.S. Route 30, turning north on Aughwick Road, and northeast on an excellent gravel road along the crest of Tuscarora Mountain.

As mapped by Pierce (1966), the outcrop is just above the base of the Lower Silurian Tuscarora Formation in an area where bedding dips gently to the west (Fig. 1). Bedding at the slightly slumped outcrop trends about N35°E, 15°NW. Neither tectonic breccia nor slickensides, potential traps for iron mineralization, were observed.

Pierce (1966) estimates that the Tuscarora Formation in this area is 520 to 600 ft thick. The sampled interval represents the basal, horizontally laminated lithofacies of the Tuscarora Formation (Cotter, 1982). General characteristics of this lithofacies in Pennsylvania include: light gray to white, fine to medium-grained sandstone units up to 90 ft thick; lack of lithic clasts or shaly interbeds; exceedingly pure sandstone containing only traces of chert and heavy minerals; and no *Arthrophycus*. *Skolithos* and *Monocraterion* are commonly present. Cotter further interprets this sequence to represent a moderate-to high-energy beach depositional environ-

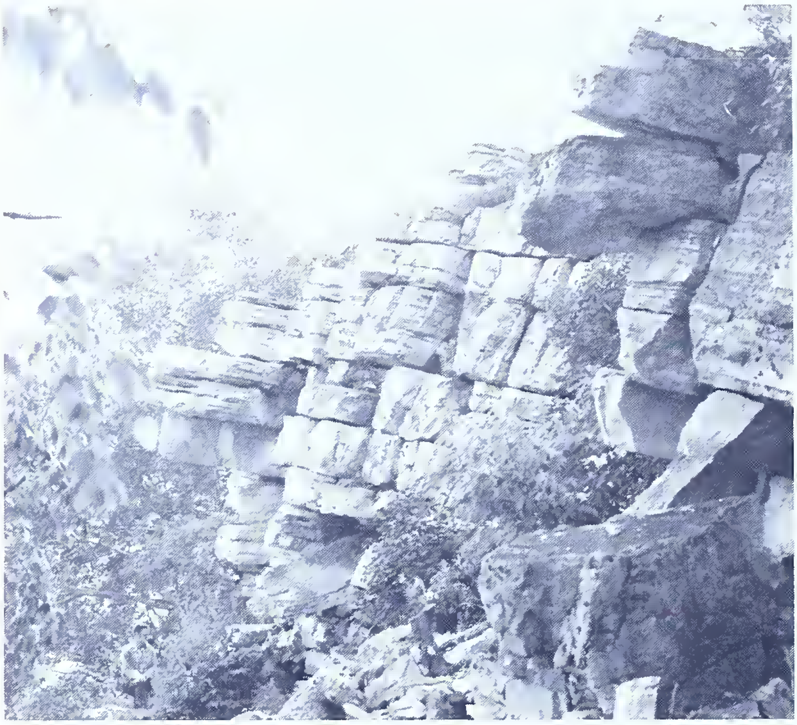

FIGURE 1.

Basal portion of Tuscarora Formation outcrop on Tuscarora Mountain looking south. Note conspicuous horizontal laminations and low dip.

ment, and suggests the supermature nature of this unit can be attributed to the abrasion of quartz grains against each other in a beach environment.

The typical bed at the sample site is 4 inches to 3 ft thick. Most of the sampled interval is composed of 0.5-to 1-mm size quartz grains, the majority of which appear to be rounded, milky or frosted quartz. Traces of monazite (?), limonite (yellow staining), anatase (?), and tourmaline (?) appear to be present. Silica cementation generally causes the rock to break through individual grains. Minor white "clay-mica" can be observed in the matrix of some of the rare, coarser grained beds. These beds are characteristically more friable, presumably due to less silica cement. A finer grained (0.25 mm) vitreous quartzite also occurs locally. These beds appear to be very pure and attain individual thicknesses of about 3 ft.

The lower limit of sampling is at a conspicuous increase in hematitic and limonitic staining. Presumably, Cotter's (1982) basal pink transitional lithofacies, or the underlying brownish-red Juniata Formation, is not far below. The base of the sampled interval is near the lower limit of exposed outcrop. The upper limit of sampling is similarly defined as the first significant occurrence of hematic and limonitic staining. About 17 ft of unsampled iron-stained sandstone is exposed in the upper part of the outcrop.

Unlike some Tuscarora outcrops in central Pennsylvania, the exposure lacks *Arthrophycus* and *Skolithos*, suggesting a depositional environment low in organics and clay. Hematitic blebs were also absent in the sampled interval, and evidence of shale clasts is rare. Because of the apparent intense weathering (discussed below), one cannot rule out the possibility that thin interbeds of shale have been removed by erosion and weathering.

A composite sample of 44 chips, obtained at approximately 15-inch intervals from the exposed beds, was analyzed for Al_2O_3 and Fe_2O_3. These results, together with corresponding data for a beneficiated sample, are tabulated below. Beneficiation consisted of leaching in two hot baths, one of 50% HCl and the other of 50% H_2SO_4, each at 80°C for 6 hours, followed by a single pass through a Frantz Isodynamic Magnetic Separator with front slope of 15°, side slope of 1°, and 1.5 A current.

	$\%Al_2O_3$	$\%Fe_2O_3$
Sampled interval, as collected	0.30	0.06
Sampled interval, beneficiated	0.06	0.06

Recognizing the strikingly low iron content, the nature of that limited iron content is worthy of note. Many individual beds within a natural outcrop are concentrically zoned with what appears to be organic and iron(?) staining (Fig. 2). From the outside in, a typical block exhibits the following zones:

A. An outer highly leached rind or pure white quartz sand about 4 mm thick.
B. A few centimeter thick intermediate zone with a sharp outer limit and a gradational inner limit and with dark brown staining (organics and iron(?)) or individual sand grains.
C. A core of nearly pure quartz assumed to be unweathered.

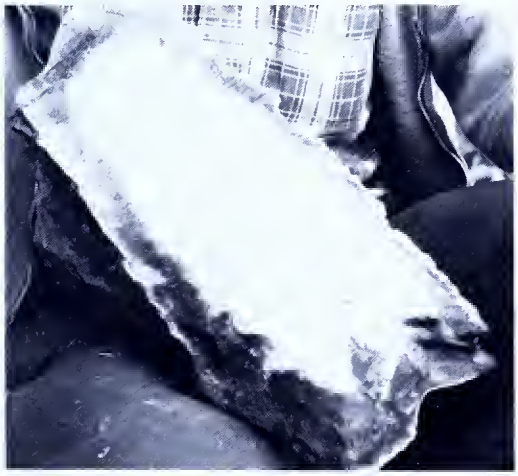

FIGURE 2. Example of color zonation thought to be related to weathering and concentration of organics and iron (?) by capillary action of rainwater.

It is postulated that the intermediate zone of organic and iron(?) enrichment is a result of weakly acidic precipitation carrying traces of dissolved organics and iron(?) from the outer layers of sandstone into the dryer interiors via capillary attraction. It is further postulated that as the rock eroded, this zone migrated inward from the new erosional surface and became more concentrated.

Interpretations of preliminary observations suggest that the sampled material could be a source for acid refractories and specialized use of high-purity silica where angular fragments of crushed aggregate are not detrimental. This occurrence appears to be of much higher quality than those heretofore reported. Previously published chemical analyses from Tuscarora outcrops and quarries in Huntingdon, Blair, Bedford, and Fulton Counties are relatively uniform with about 1% each of Al_2O_3 and Fe_2O_3 (Moore and Taylor, 1924); the previous best analyses had about 0.75% each of Al_2O_3 and Fe_2O_3 as compared to the 0.30% Al_2O_3 and 0.06% Fe_2O_3 at this Franklin County locality.

A reconnaissance study of other silica occurrences by S. W. Berkheiser, Jr. is nearing completion and will be announced in *Pennsylvania Geology* later this year. Several of the occurrences show promise of yielding mineable configurations of even purer silica. Approximately 35 samples selected from sedimentary formations and vein occurrences ranging in age from Precambrian to Pennsylvanian are being analyzed. Magnetic and acid beneficiation test results will also be reported.

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And then — Letters from Our Constituents . . . .

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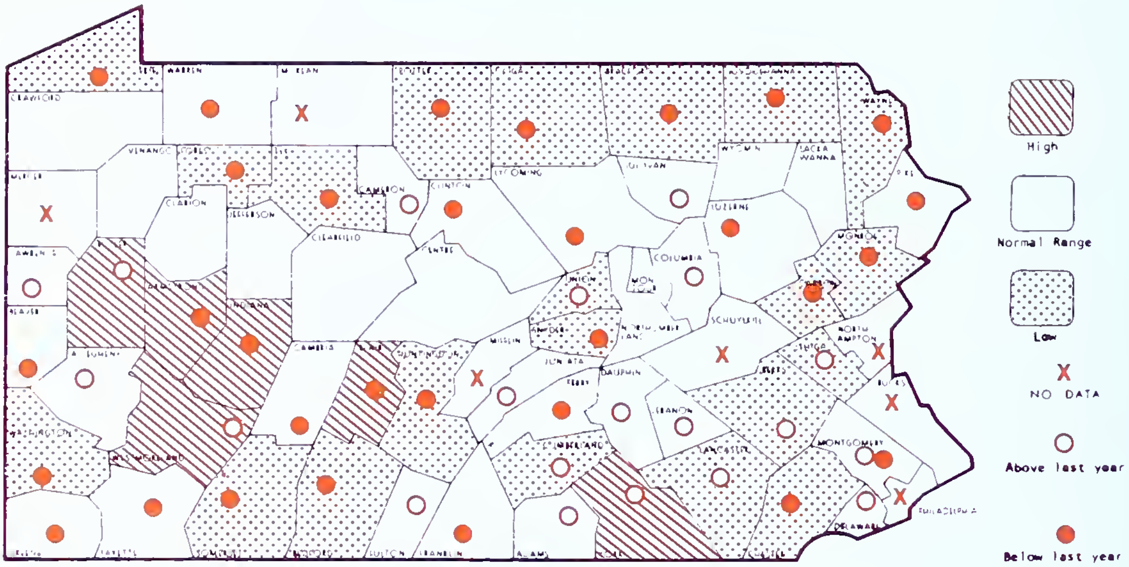

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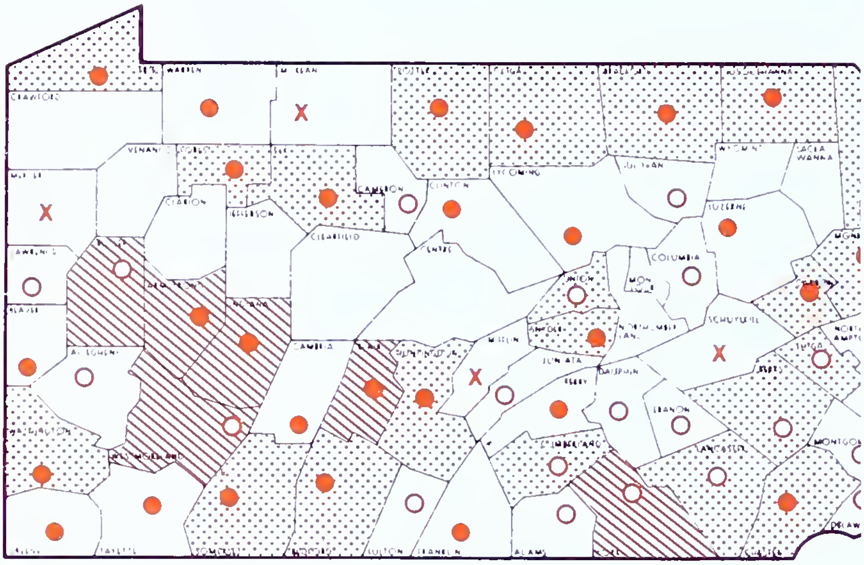

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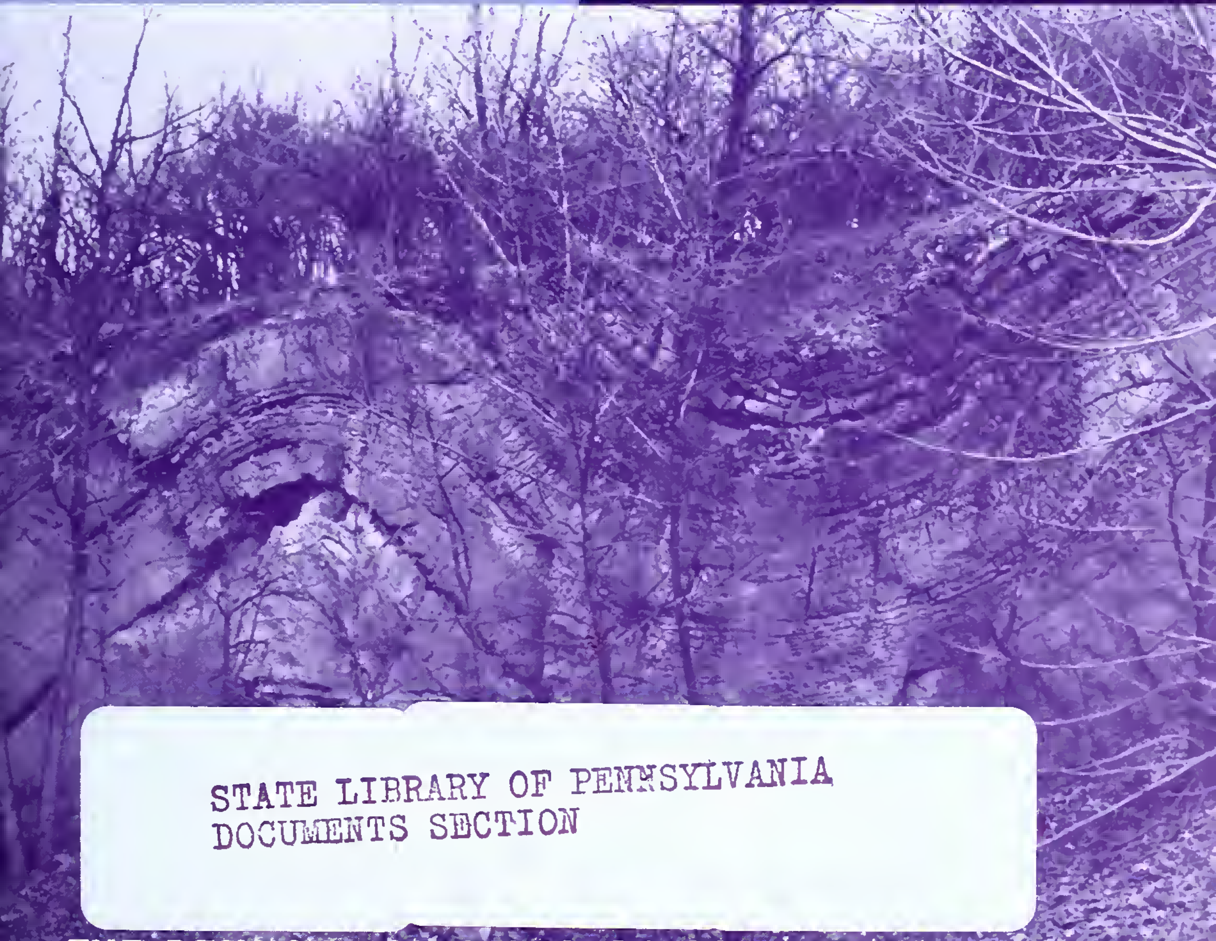

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ON THE COVER: Parallel folding of the Keyser-Tonoloway limestones, typical of the Central Appalachian structures exposed near Newport, Perry County. Photo by Denise Royer.

PENNSYLVANIA GEOLOGY is published bimonthly by the Topographic and Geologic Survey, Pennsylvania Dept. of Environmental Resources, Harrisburg, Pennsylvania, 17120.

Editor, Arthur A. Socolow; Associate Editor, Donald M. Hoskins.

Articles may be reprinted from this magazine if credit is given to the Topographic and Geologic Survey.

April 1983

FROM THE DESK
OF THE
STATE GEOLOGIST . . .

THE SHRINKING BANK ACCOUNT

If a person had $50,000 in the bank and needed $10,000 a year to live on, the savings would last about 5 years. If somehow he reduced his needs to $9,000 a year and began to earn $4,000, his savings would last 10 years.

This example is intended to illustrate today's world oil situation. True, we have learned to consume less oil. True, we are discovering some new oil fields each year. But the basic fact is that we are using up more oil each year than is being discovered. Thus, the oil reserves, like the balance in the bank is continuing to decline, albeit at a slightly lower rate than before the embargo of the 70's.

To the ones who now cast aspersions on those of us who pronounced an oil shortage and an "energy crisis", I would caution that we are really not in error. While "oil glut" has replaced "energy crisis" in the press, the fact is that for the past 20 years, and continuing today, the world oil reserves (like the bank account above) are shrinking. Thankfully, with conservation practices and increased exploration the rate of shrinkage of reserves has declined, postponing for some few years the point of critical alternatives.

The message here is neither to save face nor to gloat, but rather to stress the need for continued measures to cope with a declining balance. This calls for continuing conservation, continuing and improved exploration to locate hidden and deeper reserves, and continuing efforts to develop alternative energy resources. In Pennsylvania this translates into maintaining conservation practices, more and better oil and gas exploration, and particularly, heavy emphasis on creative development and utilization of our tremendous coal resources. Our coal deposits constitute an invaluable energy reserve upon which we must research and plan for future utilization.

"Oil glut" terminology and psychology can lull us into a false sense of security and lethargy. The "bank account" is limited; the time to prepare for the close of the "account" is now.

Arthur A. Socolow

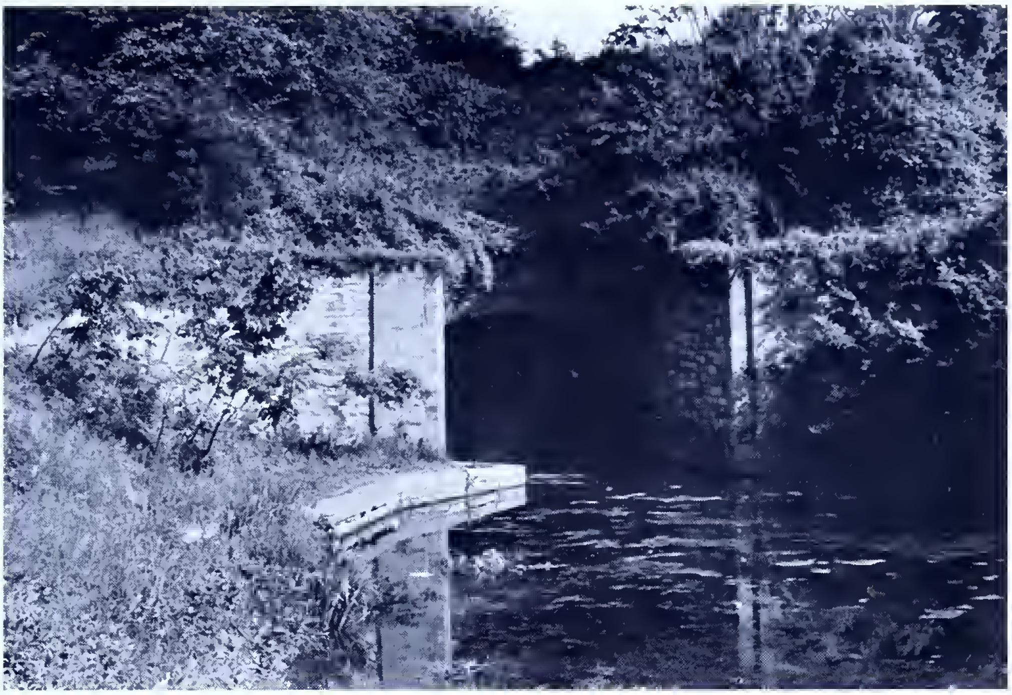
Canals of the Lebanon Valley

by William M. Jordan
Millersville State College

Because the "Lebanon Valley" lies between the Susquehanna River on the west and the Schuylkill on the east it bears a number of place names dating from the 19th century halcyon days of America's great "canal era"; names like Union Deposit, Water Works, Leesport, and Port Clinton (the last north of the valley proper). Although these settlements are mostly vestiges of their former selves, they testify to the former importance of transportation and commerce provided by artificial waterways like the Union, Schuylkill, and Pennsylvania "Main Line" canals. It can even be argued that the canals influenced, indirectly perhaps, the geologic study of the region.

The importance of British canals in the history of geology and their role in the birth of stratigraphy is personified in the career of William Smith, as is well known (Phillips, 1844; Fuller, 1969). In Pennsylvania the case can be made that the "canal mania" resulting from the success of New York's Erie Canal, completed in 1825, and the resulting rash of "internal improvements" led to establishment of the short-lived (1836-1842) First Geological Survey of Pennsylvania, under Henry Darwin Rodgers (Jordan, 1979). The Second Pennsylvania Survey (1874-1889), under J. Peter Lesley, came when canals were well under the lengthening shadow of their spiritual descendant, the railroads, an ever expanding and eventually omnipresent transportation network. The final decline and abandonment of the canals closes-out the 19th century history of the Lebanon Valley, but the memory of canals lives on in the place names that they provided.

The main waterway serving the Lebanon Valley was the Union Canal, extending as the "Golden Link to the West" between the Schuylkill Canal at Reading to the state-owned Pennsylvania "Main Line" Canal at Middletown on the Susquehanna. Its route was the first (1762) to be surveyed, and the early works were visited several times by George Washington who had an entrepreneurial interest in canals because of his holdings on the Potomac (Aungst, 1966).



Several miles of canal, including locks, were constructed between 1792 and 1794 by the Schuylkill and Susquehanna Canal Company from Myerstown to a point near Lebanon. This financially troubled firm was reorganized and chartered by the state in 1811 as the Union Canal Company. Nine years later, in 1828, 80 miles of the completed canal were officially opened but for reasons of economy, which ultimately proved unfortunate, with "narrow locks" only 8½ feet wide by 75 feet long. Not until the immediate pre-Civil War period (1851-57) was enlargement of the locks to 17 by 90 feet undertaken in order to accommodate through-boats from the connecting canals, but 1857 also saw completion of the rival Lebanon Valley Railroad. Thus, despite the company's hopes, 1835 proved to be the Union Canal's best revenue year, based on the $135,354 of tolls collected (Pawling, 1982).

The most famous engineering feature of the canal was, and still is, the summit level tunnel piercing the Martinsburg Formation in the divide between the drainages of the Tuplehocken and Swatara Creeks. This oldest surviving transportation tunnel in the United States, located and preserved in a park just east of Lebanon, was completed in 1826 with a length of 729 feet, but was shortened to 600 feet by the enlargement in the 1850's. The tunnel lacks a tow path, the boats being poled through by hand, while the mules were led over the crest on a path still visible today.

The major operating problem on the canal however, second only to the "narrow locks" as a deterrent to economic success, was the effect of porous carbonate bedrock on water levels beneath the summit level and eastward to beyond Myerstown. Elsewhere the canal is located mostly within the Martinsburg Formation. Engineering attempts to solve the dry-weather dilemma of repeated stranding of boats (lumber-laden barges would often tow their cargo behind in summer months; others had no recourse) included plank-lining several miles of trouble spots, a system of auxiliary reservoirs, and an arrangement to lift water from the Swatara Creek three miles away from the western end of the summit level. Two 40-foot waterwheels and two steam engines at the "Water Works" on the Swatara powered two pumping engines raising water 95 vertical feet to conduits connecting with the summit.

Also from this spot, a 22 mile "feeder canal" continued north along the Swatara to Pine Grove, well within the Ridge and Valley Province, where a 3.6 mile railroad, opened in 1833, gave access to the anthracite mines at Lorberry. This Pine Grove Feeder utilized, in part, slackwater navigation behind dams on the Swatara, but still had 14 locks and one aqueduct. The main Union Canal, in addition to its summit tunnel, had 92 lift locks constructed of Triassic red sandstone, and a total of 12 aqueducts.

The Schuylkill Canal, like the Pine Grove Feeder, was in large part a slackwater navigation from the coal fields near Pottsville to Philadelphia, via the river of the same name. Built in the interval between 1815 and 1827, its peak year of financial success was 1841 when revenues, mostly from the transport of anthracite, amounted to $575,861 (Patton, 1982). In the same year the parallel and rival Philadelphia and Reading Railroad was completed.

To the west, the "Main Line" of the state-built and run Pennsylvania Canal System was started in 1826 at Harrisburg (McCullough and Leuba, 1973) but did not face railroad competition until 1850 when the Pennsylvania Railroad finished its own first link, from Harrisburg to Hollidaysburg. However it was the first to lose the economic battle, being sold to the competing railroad in 1857 (Shank, 1965). Ironically, the cause of failure was dependence on the canal's own railroad components, the Columbia and Philadelphia Railroad, and particularly the ingenious but inefficient trans-Allegheny Portage Railroad between Hollidaysburg and Johnstown. Both of these railroads and inclined plane systems were capable of carrying sections of canal boat overland, a clumsy method compared to all-rail transport (Jacobs, 1941).

The first of the Lebanon Valley canals to be abandoned was the Pine Grove Feeder, washed out by a flood on the Swatara in 1862, while the Union Canal itself went under in 1885. The Schuylkill Canal was sold to the Reading Railroad in 1870 which continued it in operation, but gradual coal and culm siltation of the Schuylkill resulted in incremental abandonment from 1872 until as late as 1931. Similarly, portions of the Pennsylvania Canal system were kept in operation by a subsidiary of the Pennsylvania Railroad, the Pennsylvania Canal Company, until final abandonment in 1903. Theodore Klein's 1901 classic report to the state Bureau of Railways on "The Canals of Pennsylvania and the System of Internal Improvements" describes the final stages of disintegration of a transportation network that had opened both the Lebanon Valley and the anthracite fields to the north to commerce, thus drawing the earliest systematic attention of geologists to the region.

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These county maps are made possible because we have already completed statewide coverage of 7½-minute quadrangle topographic maps. These up-to-date quadrangle maps used for a myriad of plotting, planning and construction purposes (and used extensively by hunters in the field and on the walls of their hunting camps), now enable the preparation of county topographic maps at very moderate cost. The county maps are being constructed at the highest order of accuracy typical of the original 7½-minute quadrangle maps.

The new county topographic maps show all landforms through the use of contour lines. They also show all existing surface features including rivers, streams, lakes, swamps, as well as man-made features including roads, trails, railroads (active and abandoned), major buildings, excavations, dams, and bridges. Political boundaries including township, borough and city lines are indicated. Contours are shown in brown at 20-foot intervals, man-made features are shown in black with major roads and urbanized areas in red, forested areas are green, water features are blue, and political boundaries for townships, boroughs and cities are outlined in orange. The 1:50,000 (approximately 4000 feet to the inch) scale of these county maps was chosen to satisfy the needs of those who want to have maps with a scale somewhat like the old inch-to-mile series which was discontinued. The 1:50,000 scale also keeps us in step with the trend to utilize the metric system.

County topographic maps are now available for the following counties: Adams, Armstrong, Beaver, Berks, Blair, Carbon, Centre (east & west halves), Columbia, Crawford, Cumberland, Dauphin, Delaware, Erie, Forest, Franklin, Greene, Jefferson, Lackawanna, Lancaster, Lebanon, Luzerne, Lycoming (east & west halves), Monroe, Montour, Pike, Schuylkill (east & west halves), Sullivan and Union.

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FOSSIL PLANTS OF THE ANTHRACITE REGION

One of the Pennsylvania Geological Survey's newly published reports is *"Fossil Plants from the Anthracite Coal Fields of eastern Pennsylvania"* by Dr. John Oleksyshyn, Emeritus Professor of Geology, Boston University. Professor Oleksyshyn is a widely-known authority on paleobotany and the author of numerous scholarly papers on the Paleozoic floras of North America and Europe.

The bulk of this 157-page report consists of extremely detailed descriptions of fossil plants collected from below the main Buck Mountain (No. 5) coal bed at the famous St. Clair locality in the Southern Anthracite field and above the Upper Pittston (or Top Baltimore) coal bed at Wanamie in the Northern Anthracite field. Approximately 75 species of early Late Pennsylvania plants are described. The species belong to 12 families of "true ferns," "seed ferns," "club mosses," and "horse tails." Accompanying the systematic descriptions are 20 plates of photographs illustrating the various species. The report also includes an introductory review of the geology of the Anthracite fields, a concluding section on comparison of the described floral assemblages to those of similar geologic age in Canada, Great Britain, and continental Europe, and a relatively complete glossary of technical terms.

This report will be of particular benefit to professional paleobotanists and stratigraphic paleontologists in their work on eastern coal and coal stratigraphy. Because of its excellent illustrations of Pennsylvanian plants, however, it should also prove of interest to amateur fossil collectors, even though the localities from which the specimens were collected are not open to amateur collectors without special permission from the property owners. Plant fossils from other localities can also be identified using this book.

General Geology Report 72, "Fossil Plants from the Anthracite Coal Fields of eastern Pennsylvania," may be obtained by mail from the State Book Store, P.O. Box 1365, Harrisburg, PA 17125, at a cost of $4.30 (add 6% sales tax if mailed to a Pennsylvania address). Check made payable to the Commonwealth of Pennsylvania must accompany order.

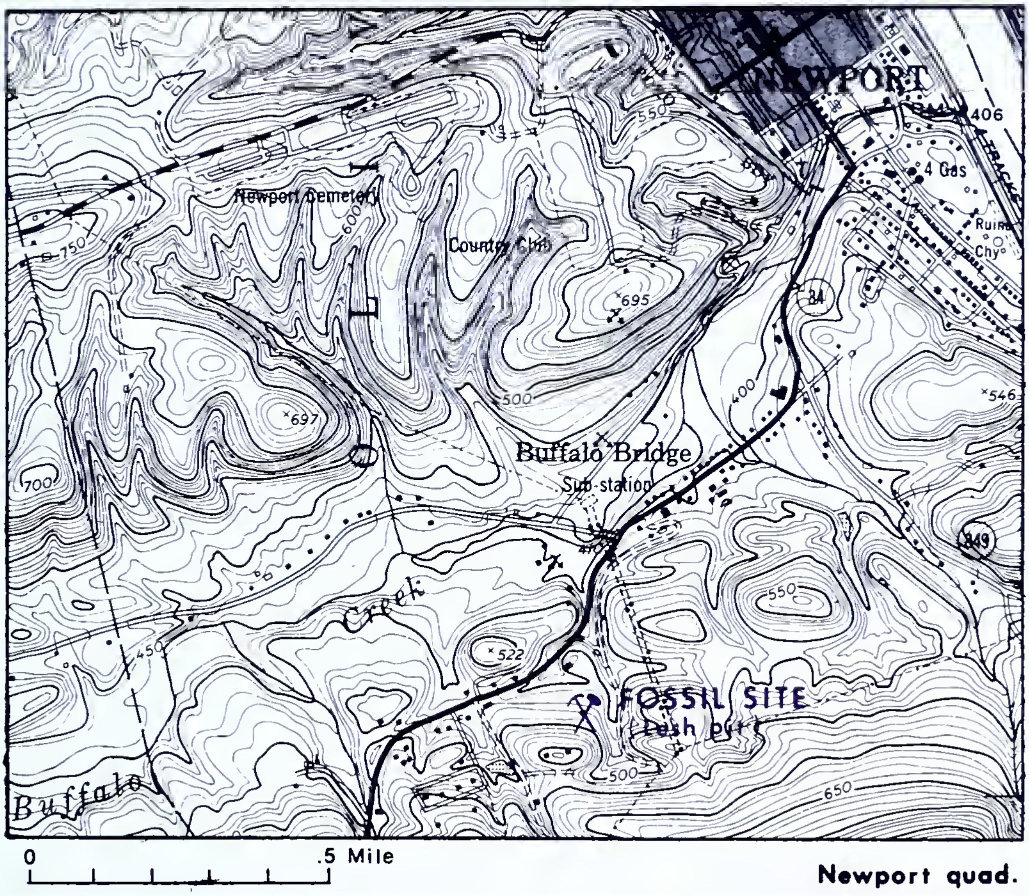
Prolific Corals and other Fossils of Devonion Age at the Lesh Borrow Pit, Perry County, Pennsylvania

by Jon D. Inners, Pennsylvania Geological Survey, and
Diane M. Nork, University of Nevada at Reno

As Nature conditioned the glacial soil in Henry Thoreau's New England garden to say "beans," so she has prompted the marine shales of the Middle Devonian Mahantango Formation in central Pennsylvania to say "fossils." More than 175 species of invertebrate fossils, including corals, bryozoans, brachiopods, bivalves, gastropods, cephalopods, trilobites, and crinoids, as well as abundant trace fossils, are known from the Mahantango in the south-central part of the state alone (see Ellison, 1965). Although many highly fossiliferous Mahantango localities have been previously noted in the geologic literature, unusual and prolific collecting sites continue to be brought to our attention.

Mr. Laurence Benander of Camp Hill, Pennsylvania, recently showed us an excellent, previously undescribed, Mahantango locality in Perry County. Not only does this site contain one of the most profuse fossil assemblages ever reported in central Pennsylvania, but it is also noteworthy in yielding exceptionally large colonies of "honeycomb" coral and numerous robust "horn" corals. The fossiliferous locality is a small shale borrow pit on the southeast side of Pa. Route 34 (500 feet south of Swartz's Car Wash), about one mile southwest of Newport (40°27′38″N/77°08′20″W, Newport quadrangle; Figure 1). The pit is owned by Mr. Harry B. Lesh of Newport. Mr. Lesh has given permission for individuals and groups to collect when equipment is not operating in the pit.

A total stratigraphic section of approximately 53 feet is represented in the Lesh pit, of which a little more than 50 percent is concealed. The exposed rock consists predominantly of medium dark gray, sparsely to highly fossiliferous, silty claystone and clay shale; several thin layers of argillaceous limestone are interbedded with the shaly units (Figure 2). Calcareous content increases upward, and the section is capped by two thin, highly fossiliferous limestone beds. These strata comprise the uppermost part of the Sherman Ridge Member and at least a portion of the thin, overlying Tully Member of the Mahantango Formation (Dyson, 1963; Faill and others, 1978).



Newport quad.

Figure 1. Location map.

Invertebrate fossils in the Mahantango Formation at the Lesh pit include more than 40 species of solitary and colonial corals, bryozoans, brachiopods, bivalves, gastropods, cephalopods, trilobites, and crinoids (Table 1). The most unusual elements of the fauna are the solitary rugose ("horn") and colonial favositid ("honeycomb") corals. Although small solitary corals and favositid colonies are found in the Mahantango at many localities in central Pennsylvania, the large "horn" corals and favositid colonies that occur in the Lesh pit are clearly not typical of the formation. Many "horn" corals of the genus *Heterophrentis* are 2 inches in diameter and 4 inches long, and the favositid colonies range up to 13 inches in diameter (Figure 3).

Three distinct fossiliferous layers may be recognized in the Lesh pit (see Figure 2). The lowest occurs near the base of the exposed Sherman Ridge Member and consists of 1.3 feet of leached argillaceous limestone and limy claystone in which bryozoans (especial-

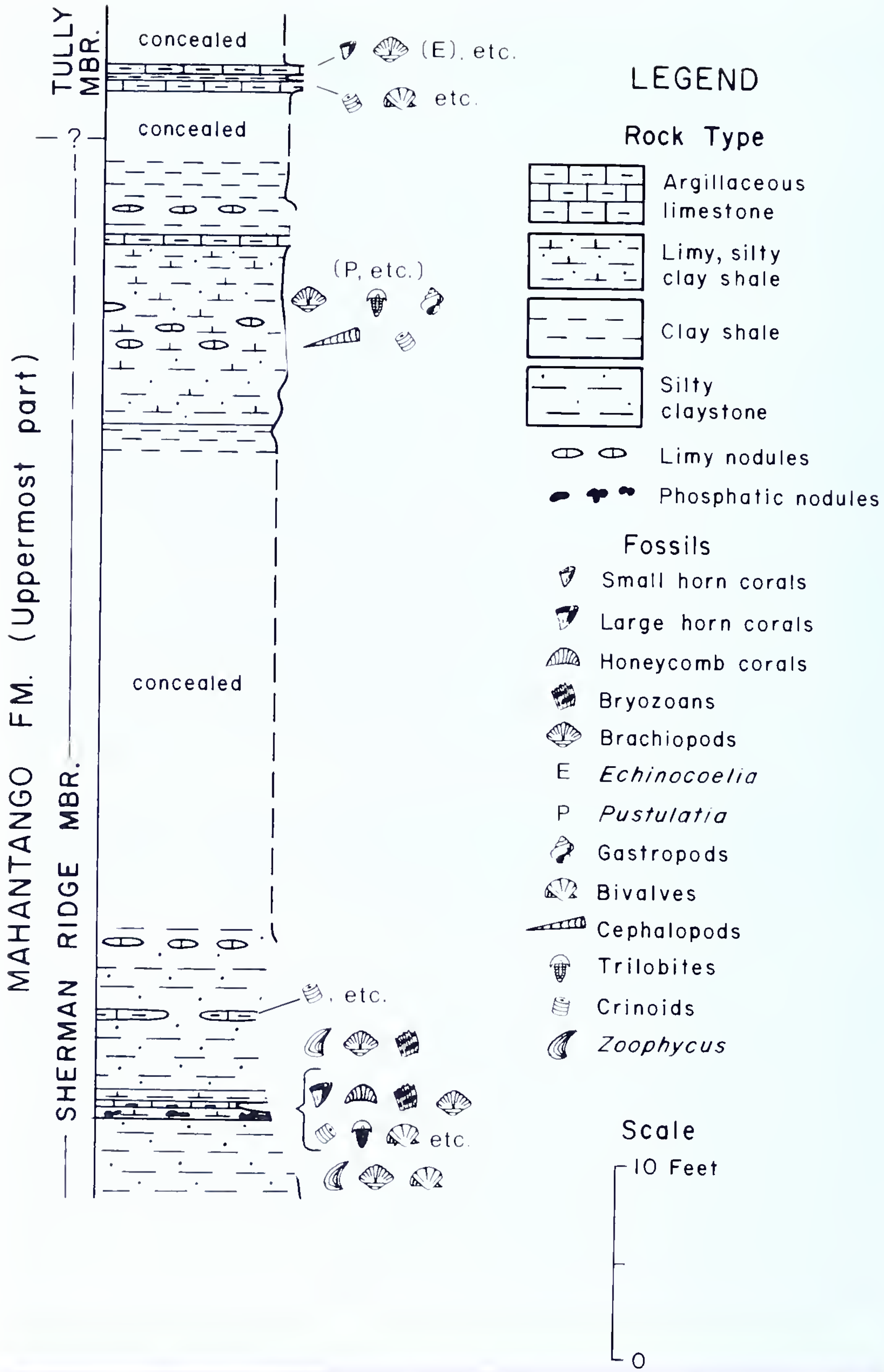


Figure 2. Columnar section of upper Mahantango Formation at Lesh pit.

ly *Fenestella*), brachiopods and corals abound. Although most of the fossils have fallen apart and are broken, many corals in the lower part are apparently in life position or only moderately disturbed. Small, whitish-weathered, phosphatic (quartz-fluorapatite) nodules occupy a single bedding surface several inches above the base of the fossiliferous beds (R. C. Smith, personal communication). Fractures in a few of these nodules are filled with clear, crystalline barite. Sparsely fossiliferous, silty claystone above and below the fossil layers contains *Zoophycus*, a spiral trace-fossil that is believed to result from the activity of a deposit-feeding, worm-like organism. The middle fossiliferous zone consists of approximately 10 feet of dark gray, limy clay shale near the top of the Sherman Ridge Member. The brachiopod *Pustulatia* is abundant throughout this interval, being associated with *Spinocyrtia*, *Longispina*, *Palaeozygopleura*, *Phacops*, *Bactrites*, and numerous other invertebrates. The two beds of Tully limestone at the top of the section comprise the uppermost fossiliferous zone. Swarms of *Echinocoelia* occur in the upper limestone bed.

The upper part of the Mahantango Formation (as represented in the Lesh pit) was deposited during a brief expansion of the shallow, subtropical epicontinental sea that covered central Pennsylvania in Middle Devonian time (about 385 million years ago). This transgressive episode followed deposition of a large sandy delta complex (Montebello sandstone and related coarse clastics) which was spread over a broad arcuate area centered on the south at the present position of Harrisburg. As the transgression of the sea pushed the shoreline farther to the southeast, most land-derived detritus was deposited as a result of shoreline processes. Land-derived sediment supplied to the more remote parts of the Mahantango

Figure 3. Large, domal colony of *Favosites* sp. from coralline beds of Sherman Ridge Member. Collected in apparent growth position by William Einzig, Director of the Whitetail Environmental Center, West Shore School District, New Cumberland, Pennsylvania.

- Corals
  - *Favosites* sp . . . u
  - *Pleurodictyum styloporum* (Eaton) . . . u
  - *Heterophrentis* sp . . . *c*
- Bryozoans
  - *Fenestella emaciata* Hall . . . *a*
  - *Sulcoretepora incisurata* (Hall) . . . *c*
  - *Taeniopora exigue* Nicholson . . . u
- Brachiopods
  - *Schizophoria* sp . . . u
  - *Rhipidomella penelope* (Hall) . . . f
  - *R. vanuxemi* (Hall) . . . f
  - *Tropidoleptus carinatus* (Conrad) . . . u
  - *Megastrophia (Megastrophia) concava* (Hall) . . . f
  - *Protoleptostrophia perplana* (Conrad) . . . f
  - *Douvillina (Douvillina) inaequistriata* (Conrad) . . . f
  - *Devonochonetes* sp . . . f
  - *Longispina mucronatus* (Hall) . . . u
  - *Spinulicosta spinulicosta* (Hall) . . . r
  - *Cupulorostrum* sp . . . u
  - *Atrypa reticularis* (Linnaeus) . . . *c*
  - *Spinatrypa spinosa* (Hall) . . . f
  - *Ambocoelia umbonata* (Conrad) . . . u
  - *Echinocoelia ambocoeloides* (Cooper and Williams) . . . *a*
  - *Pustulatia pustulosa* (Hall) . . . a
  - *Delthyris sculptilis* (Hall) . . . *c*
  - *Mucrospirifer mucronatus* (Conrad) . . . f
  - *Spinocyrtia granulosa* (Conrad) . . . *c*
  - *Mediospirifer audaculus* (Conrad) . . . f
  - *Elita fimbriata* (Conrad) . . . r
- Gastropods
  - *Platyceras* sp . . . u
  - *Palaeozygopleura delphicola* (Hall) . . . u
- Bivalves
  - *Nuculites* sp . . . u
  - *Palaeonello* sp . . . u
  - *Ptychopteria (Actinopteria) decussata* (Hall) . . . f
  - *Modiomorpha concentrica* (Conrad) . . . u
  - *Goniophora (Goniophora) hamiltonensis* (Hall) . . . u
  - *Paracyclas lirata (Conrad) . . . r*
  - *Cypricardella bellastriata* (Conrad) . . . u
  - *Cypricardinia indenta* (Conrad) . . . u
  - *Orthonota undulata* (Conrad) . . . u
  - *Grammysioidea arcuata* (Hall) . . . f
- Cephalopod
  - *Bactrites* (?) *aciculum* (Hall) . . . u
- Trilobites
  - *Dechenella (Monodechenella) macrocephala* (Hall) . . . r
  - *Trimerus (Dipleura) dekayi* (Green) . . . u
  - *Phacops rana* (Green) . . . c
  - *Greenops (Greenops) boothi* var. *calliateles* (Green) . . . f
- Crinoid
  - Columnals . . . *a*
- Trace Fossil
  - *Zoophycus* sp . . . *c*

Table 1. Fossils in the Mahantango Formation at the Lesh borrow pit. (a = abundant; c = common; f = frequent; u = uncommon; and r = rare).

basin, therefore, was greatly reduced. At the same time, the calcareous content of the off-shore bottom sediments increased.

Marine organisms thrived in the warm, well-oxygenated, nutrient-rich waters of this late Mahantango sea, especially in areas where shoals formed for brief periods of time and permitted the growth of biostromes within the lower part of the sunlit zone. The most abundant organisms inhabiting the sea floor under these favorable conditions were suspension-feeding brachiopods, bryozoans, and crinoids. Solitary rugose and colonial favositid corals multiplied locally in shallow areas that had minimum sedimentation rate and maximum water clarity. Beneath the depositional surface, soft-bodied "worms" foraged through the organic-rich muds. In extremely sediment-starved areas, phosphatic nodules formed from solutions released by the decay of dead organisms and fecal material.

Periodic agitation of the sea floor is indicated by the thin layer of fossil debris that directly overlies the phosphate-nodule bed in the Lesh pit. Perhaps storm-generated waves or bottom currents swept rapidly over the area, tearing up the crinoid-bryozoan "gardens" and strewing skeletal fragments in windrows across the sea floor.

The highly calcareous, fossiliferous shales of the uppermost 20 feet of the Sherman Ridge Member and the thin, *Echinocoelia*-rich limestones of the Tully Member mark the final stages of the late Middle Devonian transgression. Following deposition of these beds, black, barren, anoxic muds (Harrell Formation) spread into the area. The non-calcareous Harrell sediments record the beginning of the regression which culminated later in deposition of the Upper Devonian Catskill delta complex.

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FRANKLIN COUNTY MINERAL CLUB SHOW

The Franklin County Rock and Mineral Club is sponsoring their sixth annual show, "Treasures from Nature" May 14 and 15, 1983, at the Chambersburg Middle School, McKinley Street and Stougger Avenue, Chambersburg, PA. Hours are Saturday 10:00 a.m. to 7:00 p.m. and Sunday 11:00 a.m. to 5:00 p.m. There will be various demonstrations and displays by club members. There will be displays for "Minerals for Minors" and, a new feature this year, "Minerals for Adults".

For more information contact Pat Hoyer, 8810 Rowe Run Road, Shippensburg, PA 17257. Telephone (717) 532-6058

Pennsylvania Loses a Distinguished Geologist

On September 7th Dr. Charles Poth passed away at his home in Camp Hill, PA. Dr. Poth was a retired staff member of the U.S. Geological Survey and past co-operator with the Bureau of Topographic and Geologic Survey; he was an outstanding hydrogeologist throughout his career of almost 25 years. For those who knew Dr. Poth, or "Charlie" as his friends called him, his mathematical mind, and his friendly, soft-spoken personality will always be remembered.

In July of 1955, Dr. Poth, a graduate of the University of Buffalo and Pennsylvania State University, came to the Pennsylvania District of the U.S. Geological Survey where he remained until his retirement in December, 1979. Prior to that time and while serving with the U.S. Army, he was a scientist assigned to the Manhattan Project. Many of our younger readers will not recognize that significance, but being chosen was an honor and the project remains a milestone in U.S. history.

The Pennsylvania Geological Survey published ten major reports that he wrote on the groundwater resources of our Commonwealth. His best-known studies were the Survey's reports: "The Geology and Hydrology of the Mercer Quadrangle, Mercer County", "Hydrology of the Metamorphic and Igneous Rocks of Central Chester County", and "The Hydrology of the Martinsburg Formation in Lehigh and Northampton Counties".

With his passing, the Pennsylvania Geological Survey, the U.S. Geological Survey, and the field of hydrogeology lost one of its most versatile and likable men. His works remain a lasting monument to his ability. It is impossible to write an adequate summary of any person's life, but he exemplified a blending of gentle friendliness and scientific know-how.

Dr. Poth is survived by his wife, two daughters and two sons.

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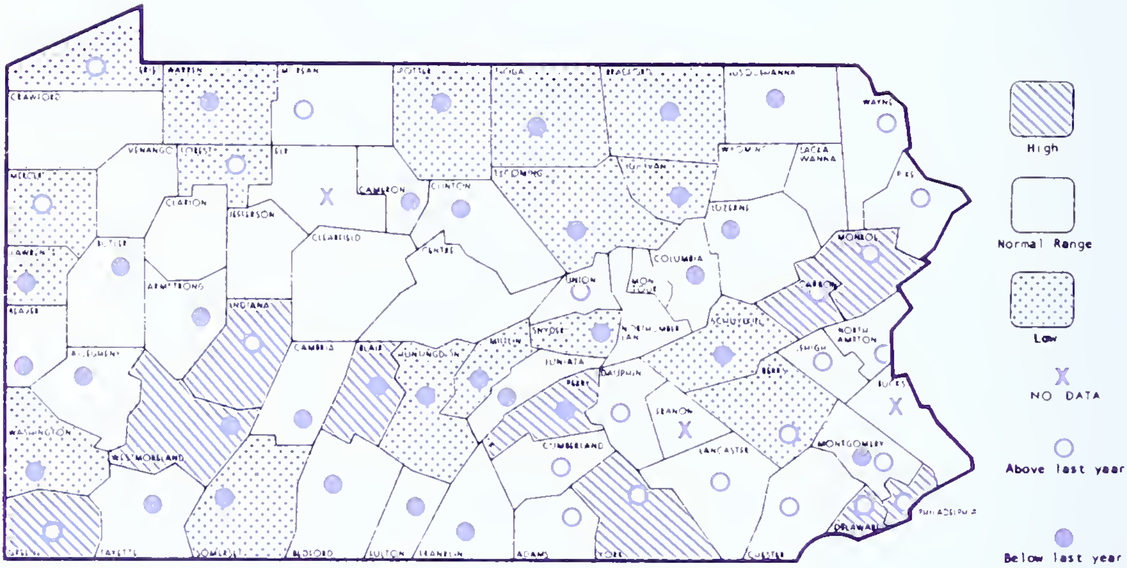

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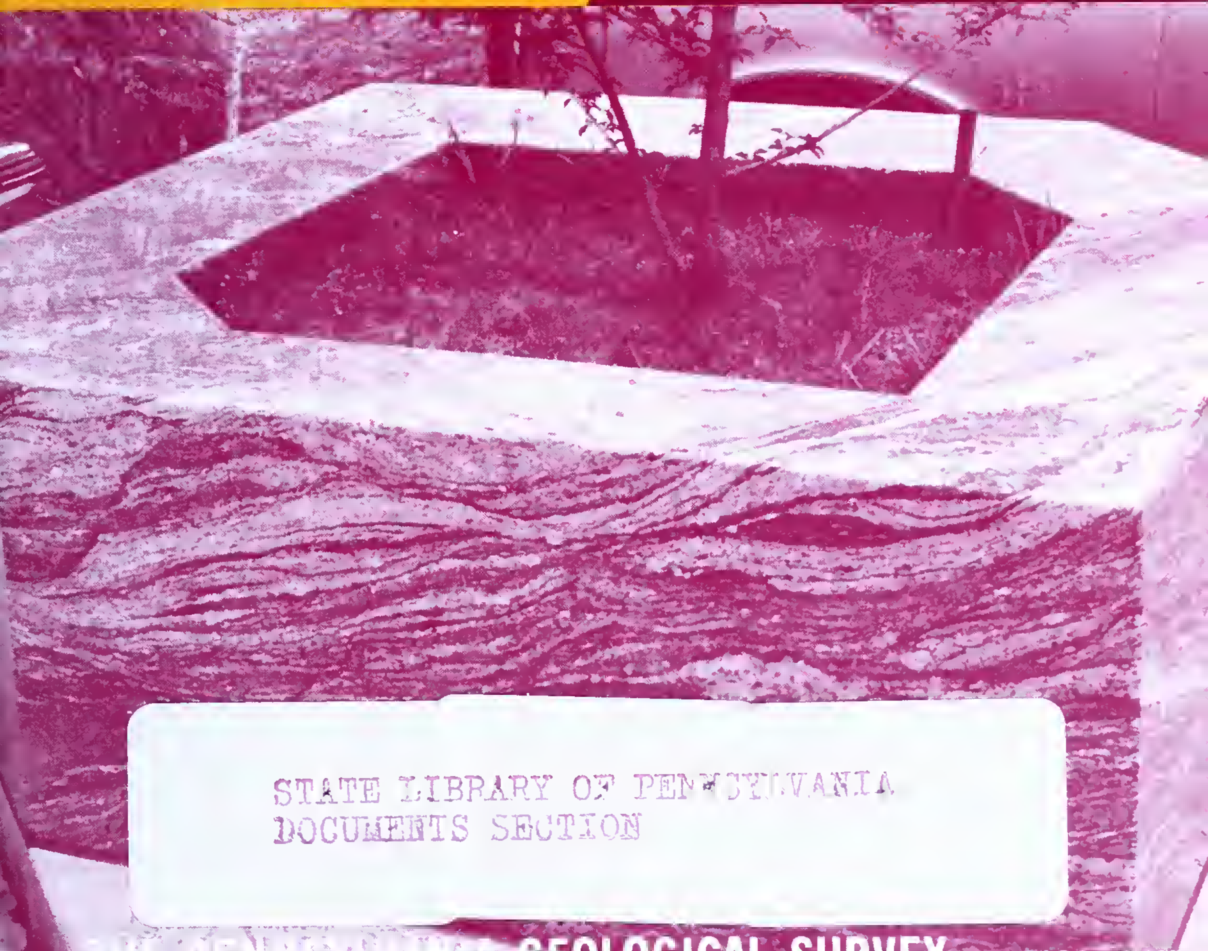

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ON THE COVER: A stone planter cut from a single block of migmatitic granite; the texture of the stone reveals its complex geologic origin. This is one of a number of such planters located in the parking area adjoining the Commonwealth's Health and Welfare Building, Commonwealth Avenue, Harrisburg.

PENNSYLVANIA GEOLOGY is published bimonthly by the Topographic and Geologic Survey, Pennsylvania Dept. of Environmental Resources, Harrisburg, Pennsylvania, 17120.

Editor, Arthur A. Socolow; Associate Editor, Donald M. Hoskins.

Articles may be reprinted from this magazine if credit is given to the Topographic and Geologic Survey.

June 1983

FROM THE DESK
OF THE
STATE GEOLOGIST . . .

GEOLOGISTS FACING THE ANGRY PUBLIC

Years ago geological work entailed basic mapping of the rock formations and mineral deposits with accompanying research to unravel the processes and conditions by which these earth resources were formed. Such endeavors constituted the stimulating, scientific activities in the wonderful world of geology.

Geologists today, particularly those in government service, have a broader scope of work responsibilities. Now we have to deal with the interrelationship of geology to societal activities and we are involved with issues such as suitable sites for hazardous waste disposal, evaluating the geologic safety of nuclear power plant locations, locating groundwater resources of sufficient quantity and quality suitable for public water supplies, assessing the geologic and hydrologic safety of proposed radioactive waste disposal sites, and determining whether certain potentially hazardous mineral constituents are present in our building materials (e.g. certain forms of asbestos) or our fuels (e.g. mercury or selenium).

Since these issues with which geologists are now involved deal with health and safety, there is a heavy responsibility upon the involved geologists to be particularly accurate and careful in their investigations. And because from the public standpoint these issues are matters of great concern, discussions over them become heated and highly emotional. Many geologists, therefore, long accustomed to dealing with rocks that don't talk back, are faced with the challenge of having their geologic findings face up to public scrutiny, including public doubts and hostility. This is an application of geology which is generally not taught in the colleges, yet it is extremely important, for it represents our geologic science at the interface with society's needs and concerns. It's not easy to face an angry, doubting audience of non-scientists and make a convincing presentation. But that's the challenge that many geologists must now be prepared to face.

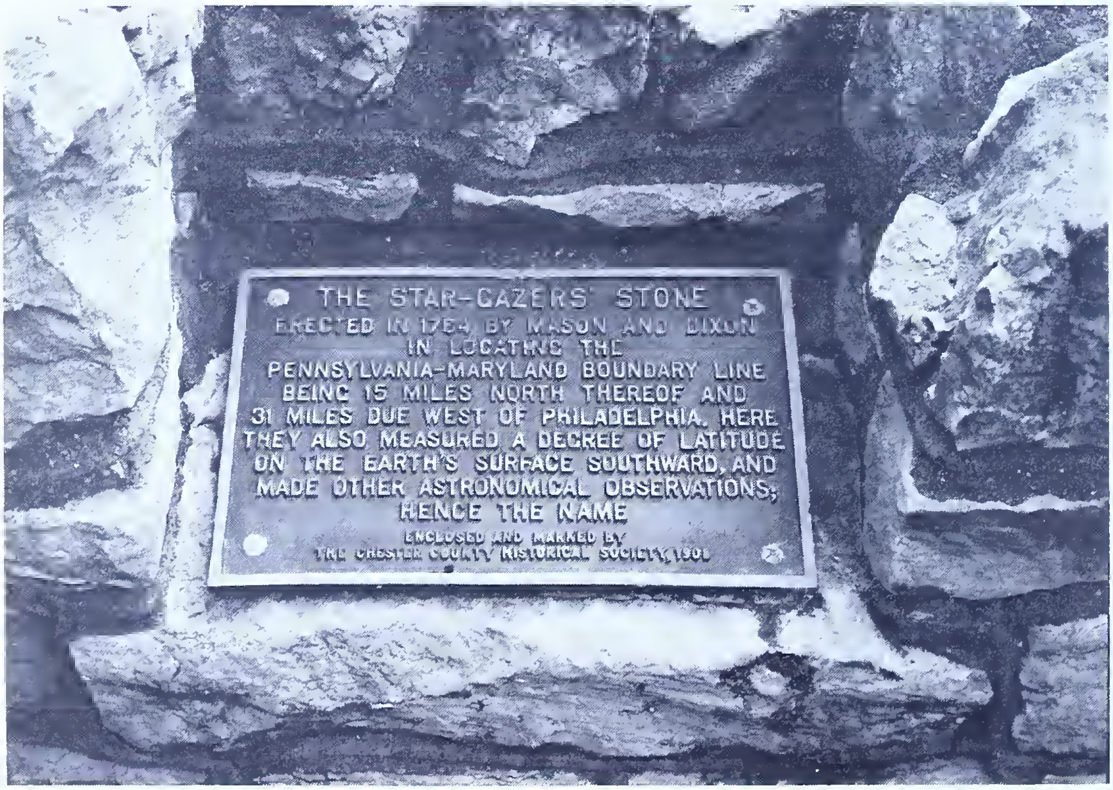
Arthur A. Socolow

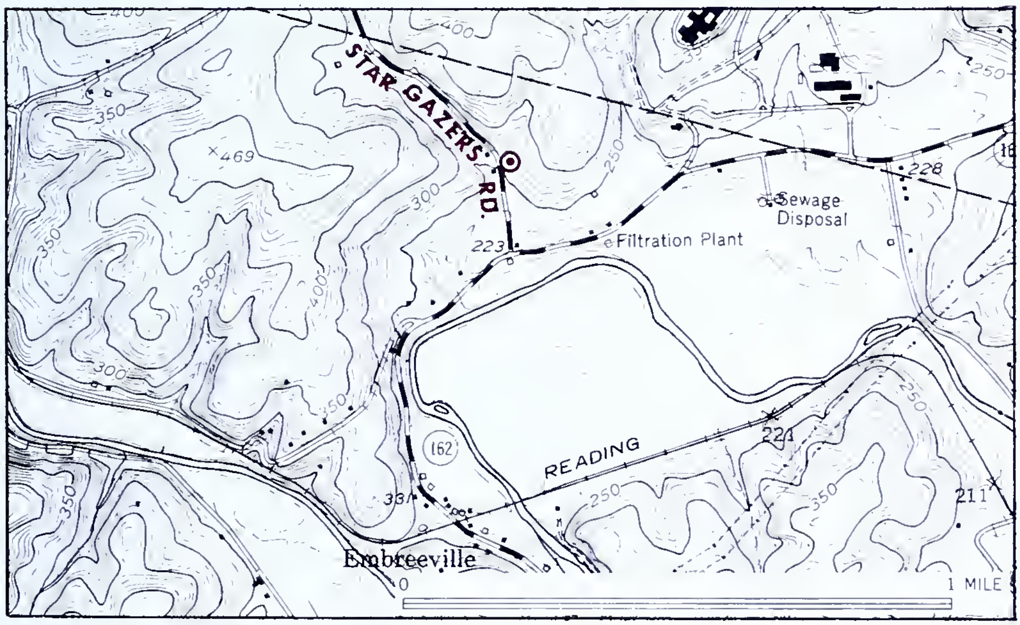
The Star-Gazers Stone

by Alan R. Geyer
Pennsylvania Geological Survey

In granting charters for America's colonies, the King of England often paid little attention to exact boundaries. One of the most famous boundary disputes arose between William Penn (Pennsylvania) and Lord Baltimore II (Maryland). They died still bickering over this dividing line. Their heirs resolved the problem by hiring a young astronomer named Charles and a surveyor/astronomer named Jeremiah.

In 1764, these two gentlemen had to use the stars to locate the southern tip of Philadelphia; the PA-MD boundary was then 15 miles due south. However, that would have been New Jersey, so they had to travel west to clear the Great Arc that formed the north boundary of Delaware. Their mission was to find a reference point due west of the southern tip of Philadelphia and 15 miles north of the PA-MD "boundary."


THE STAR-GAZERS' STONE
ERECTED IN 1764 BY MASON AND DIXON
IN LOCATING THE
PENNSYLVANIA-MARYLAND BOUNDARY LINE
BEING 15 MILES NORTH THEREOF AND
31 MILES DUE WEST OF PHILADELPHIA. HERE
THEY ALSO MEASURED A DEGREE OF LATITUDE
ON THE EARTH'S SURFACE SOUTHWARD, AND
MADE OTHER ASTRONOMICAL OBSERVATIONS;
HENCE THE NAME
ENCLOSED AND MARKED BY
THE CHESTER COUNTY HISTORICAL SOCIETY, 1908


STAR GAZERS' RD.
400
350
×469
300
250
223
228
Filtration Plant
Sewage Disposal
162
READING
224
331
211
Embreeville
0
1 MILE

By March of 1764, with the use of their sensitive instruments, they found the spot. They marked this location with a large layer of vitreous quartzite, henceforth known as the Star-Gazers Stone. To the best of our knowledge this quartz layer came from a nearby exposure of the Setters Quartzite.

From the Star-Gazers Stone they cut a straight line 15 miles south to the exact point from which Charles Mason and Jeremiah Dixon surveyed Pennsylvania's southern boundary, the Maxon-Dixon Line.

The Star-Gazers Stone may be seen today along Star Gazers Road in Chester County near the village of Embreeville. From this stone, Mason and Dixon surveyed their way into American history.

Mineral Research Fund

In keeping with its primary goal of advancing the scientific understanding of mineralogy, the Pennsylvania Chapter of Friends of Mineralogy has created a Memorial Fund, monies from which will go to support research on the minerals of Pennsylvania. The Chapter will award grants ranging from $50 to $250 to eligible students from this fund as a tribute to past members and colleagues.

Full-time graduate and advanced undergraduate students in accredited colleges and universities throughout the United States and Canada may apply. Projects including both field and laboratory studies which characterize a mineral's composition, optical properties, density, crystallography, habit and paragenesis are encouraged. Problems in geochemistry, petrology, ore, microscopy, fluid-inclusion studies, and field mapping will also be considered if closely related to Pennsylvania mineralogy. Research within surrounding states will be considered if similar occurrences are likely within the Commonwealth. Support may be utilized for field expenses, field and laboratory equipment for the department, research supplies, thin sections, instrument fees, analyses or references purchased for an institutional library.

Grants will be awarded semi-annually on October 15 and February 15. Completed applications must be post-marked no later than one month before the award date. Further details and applications are available from Mr. Donald Schmerling, 1780 Prescott Road, York, PA 17403. It is the hope of the members of the Pennsylvania Chapter that in honoring its past members and friends in this manner, the Memorial Fund will ensure continuing research in Pennsylvania mineralogy to the benefit of all.

Is There a Fault in Our Gap?

by

Joseph P. Theisen

The grandeur and natural beauty of Susquehanna Gap, north of Harrisburg, Pennsylvania, has long attracted the attention of all who travelled northward from the Great Valley. The Gap is also of interest for the wealth of geologic information it provides. It is one of the few localities where the rocks of Blue Mountain may be seen in cross-section.

A new roadcut along U.S. Route 22-322 on the east side of the gap at Rockville provides a unique opportunity to compare the stratigraphy and structure on opposite sides of Susquehanna Gap and sheds light upon a possible structural control of the location of the gap. The rocks on the east side show more deformation and contain different rock types than the section on the opposite side of the gap. A prefolding, strike-slip fault under the river in the Gap may explain these features.

STRATIGRAPHY

The five formations in the Gap are, from bottom to top: Martinsburg (shale), Juniata (sandstone and conglomerate), Tuscarora (sandstone), Rose Hill (sandstone and shale), and Bloomsburg (sandstone and shale). Dyson (1967) identified distinctive subdivisions in the Tuscarora and Rose Hill Formations on the west side. The Tuscarora here consists of a lower unit of thickly bedded quartz sandstones with little shale, and an upper unit characterized by thinner beds and a greater amount of shale. Five subdivisions in the Rose Hill include two sixty-foot-thick shale zones which occur between resistant quartzitic and hematitic sandstones.

The Tuscarora is correlated across the Gap by the basal quartzite which can be found on both sides (Figure 1). With the exception of the basal quartzitic member of the Tuscarora, no other individual rock units persist across the Gap.

STRUCTURE

The rocks of the Susquehanna Gap are subvertical and those on the east side of the gap are more deformed than those on the opposite side. The western outcrop contains minor extension faults and abundant joints. Extensional faulting is also present in nearby exposures to the north in the Mahantango Formation exposures in Little Mountain (Cloos and Broedel, 1943).

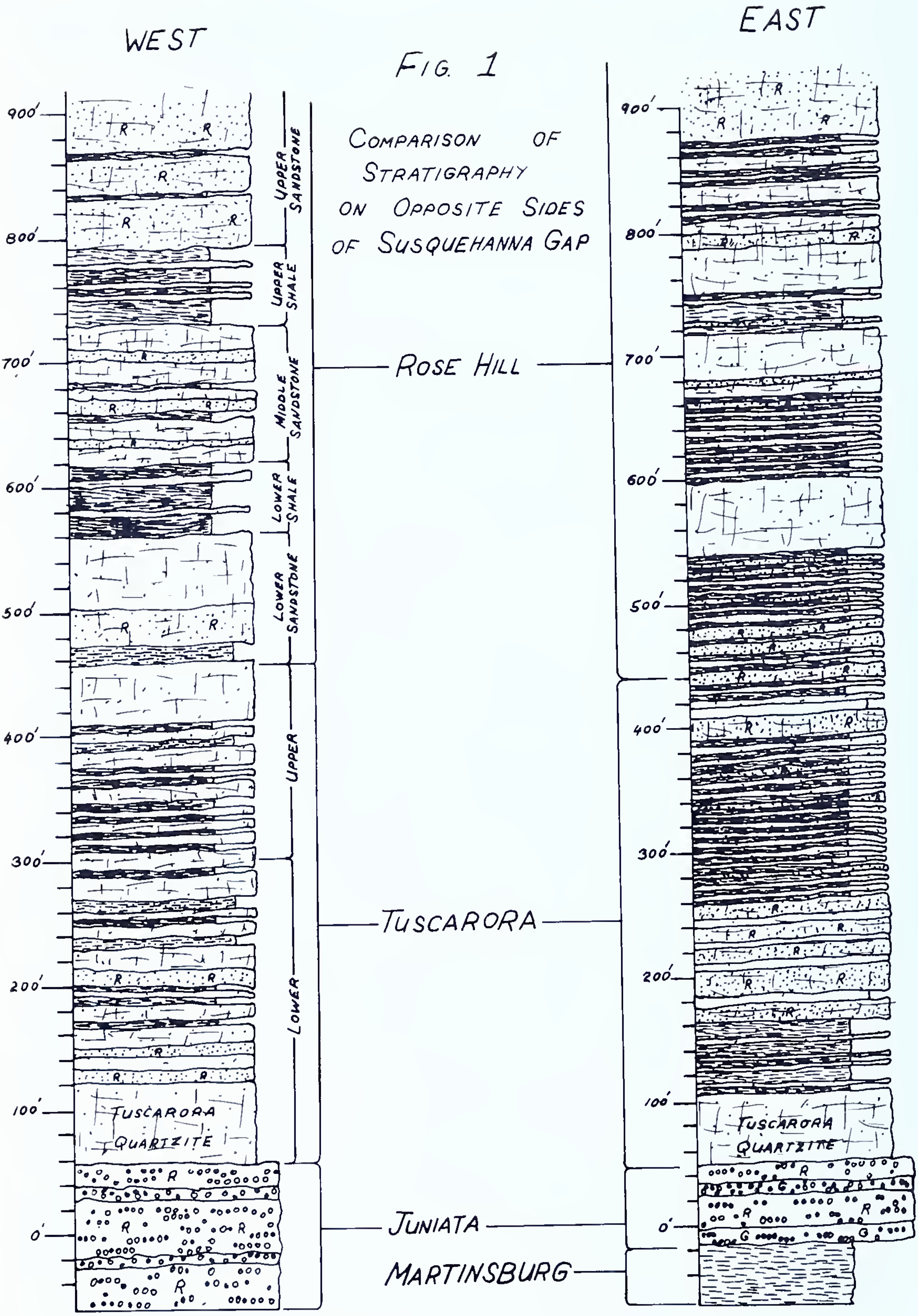


FIG. 1

COMPARISON OF STRATIGRAPHY ON OPPOSITE SIDES OF SUSQUEHANNA GAP

Compressional features found in the highly strained rocks of the east side include wedge faults and kink bands (Figure 2). Intrabed wedge faults are very common, both singly and in conjugate sets; they occur at small angles to bedding and in places follow pre-existing planes such as cross-bedding surfaces (470′ in Fig. 2). Thrust faults cutting through several beds and measuring up to 30 feet in displacement are less numerous (790′ in Fig. 2). Trends of slickensides on these compressional faults are perpendicular to fault-bedding intersections, and when beds are rotated to horizontal, indicate a greatest principle stress in the plane of bedding. These low-angle reverse faults are therefore one of the earliest structures present.

Kink bands, which also occur singly and as conjugate sets, form conjugate, or "box" folds at their intersections (300′ and 320′ in Fig. 2). These conjugate kink structures are not symmetric to bedding implying that small-scale folding began after the start of major folding.

The most common extensional features are conjugate sets of faults which are oriented at 60° to 90° to bedding. One fault set, the dominant one, dips approximately 30°N, whereas the other is generally horizontal. Displacements on faults range upwards to 150 feet (660′ in Fig. 2). Extension also occurs in the form of incipient boudinage (pinch and swell) (365′ in Fig. 2). Both incipient boudinage and extensional faulting are extremely common in the outcrop. Since extension faults offset all other structures, they occurred late in the deformational sequence, post dating both the compressional reverse faults and the kink folding.

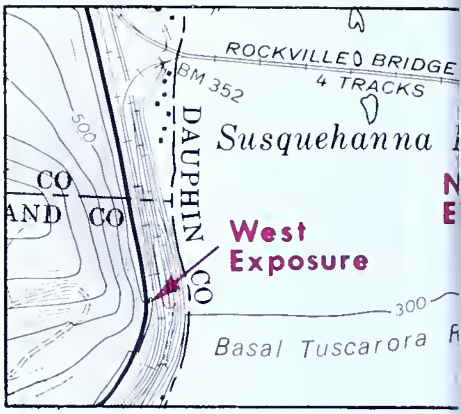
The Lower Tuscarora rocks at the southern end of the new outcrop are more highly strained than the rest of the exposure. This increased strain appears to result from a thrust fault which has moved the Martinsburg over the Juniata and brought it into contact with the basal quartzitic member of the Tuscarora (0′-50′ in Fig. 2). The orientation and sense of movement of the thrust fault imply that it occurred late in the deformational sequence during the last stages of folding. The thrust fault is not offset by extensional faults, also indicating that it is a late feature.

POSSIBLE ORIGIN OF SUSQUEHANNA GAP

Major water gaps generally imply zones of weakness in the rocks through which drainage developed. Studies of Cumberland Gap (Rich, 1933) in western Virginia and of the Delaware Water Gap (Epstein, 1966) in eastern Pennsylvania describe offset of ridges caused by differing bedding dips on opposite sides of the gaps and

FIG. 2 GEOLOGIC DIAGRAM OF THE EAST SIDE OF SUSQUEHANNA GAP

(OUTCROP APPEARS AS SEEN FROM BELOW)



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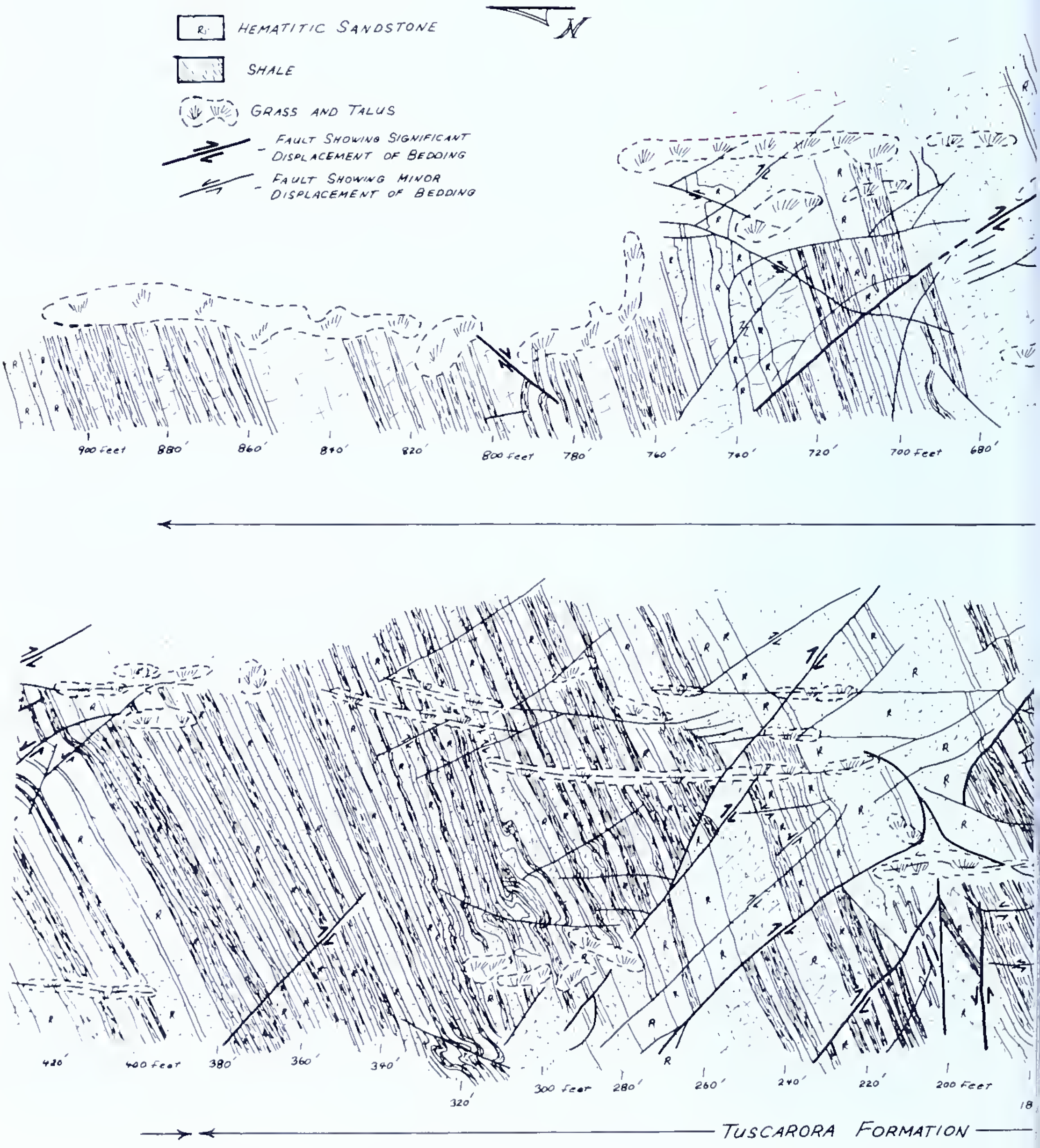

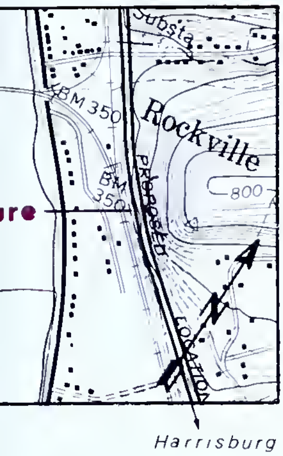
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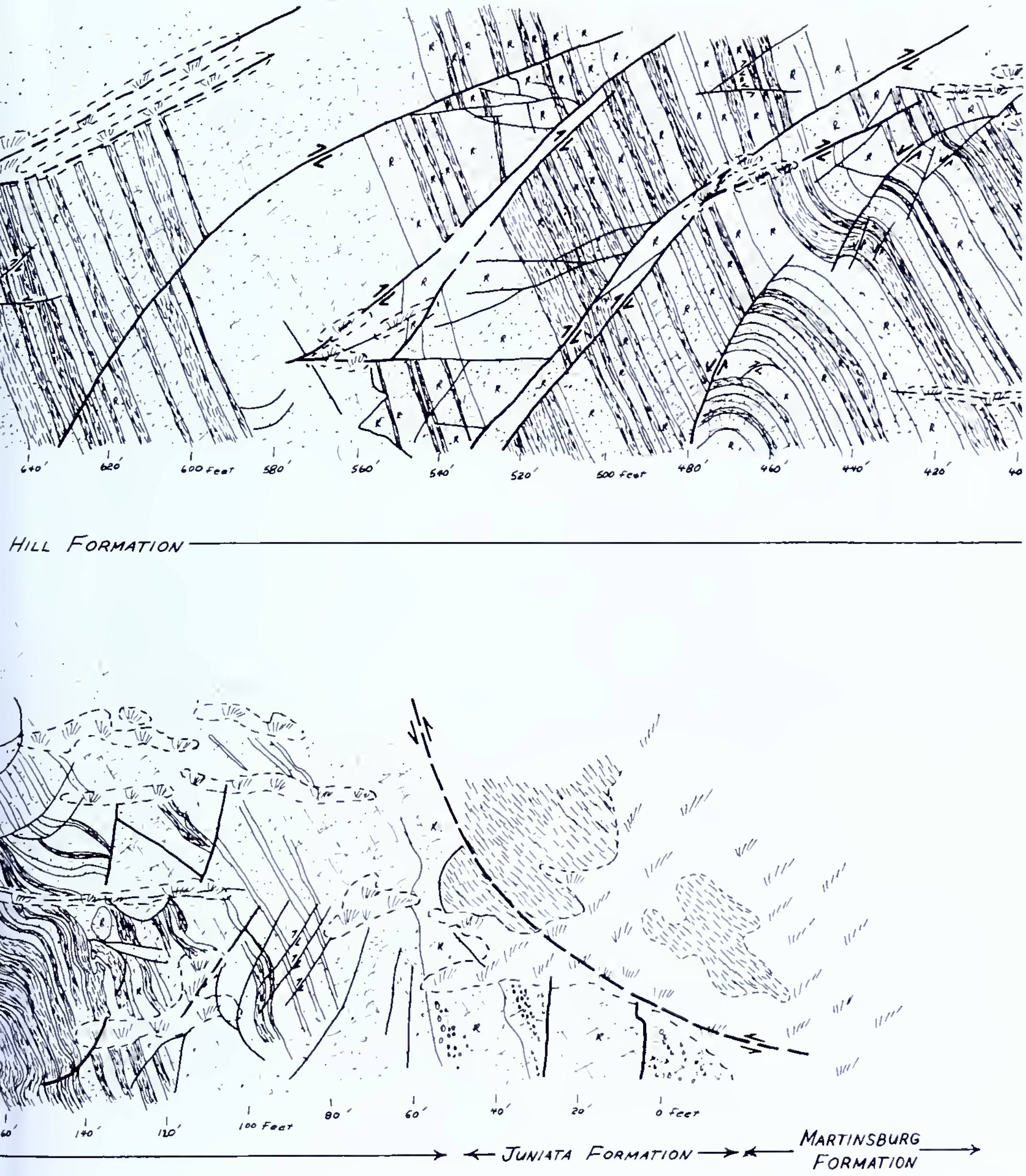
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suggest that post- or synfolding, transverse or strike faults are responsible for the location of the gaps.

At Susquehanna Gap, however, bedding dips are identical on opposite sides and therefore it is unlikely that a large-displacement, late-stage fault is responsible for Susquehanna Gap. The structure which controlled the location of the Gap is possibly a prefolding wrench fault. Such a fault, caused by shear between independently advancing thrust blocks, would correspond to the prefolding, small-scale wrench faults described by Nickelsen (1979) in the sequence of deformation at the Bear Valley Strip Mine.

The presence of a prefolding wrench fault in Susquehanna Gap could account for the various features found in and adjacent to the Gap. The unusually high degree of deformation seen only in the new outcrop could result from a narrow wrench zone cutting obliquely through the wide gap, closer to the east side than the west. Air photos show the riffle in the Susquehanna River (Figure 1, index map) caused by the resistant basal Tuscarora quartzite apparently undeformed. The riffle ends abruptly as it approaches the east bank where the river flows on alluvium. The area between the east end of the riffle and the gap outcrop could contain a wrench (tear) fault.

In summary, the interpretation that a prefolding, large-scale wrench fault caused the structural weakness that controlled Susquehanna Gap is based on the following: (1) no offset of ridges is seen across the gap, hence the structure causing the gap cannot be a postfolding wrench fault; (2) while late extensional structures are found at all nearby exposures, prefolding compressive deformation (wedges, thrusts, and kink folds) occurs only in the rocks on the east side of Susquehanna Gap, suggesting that a major prefolding wrench fault passes close to this outcrop; (3) poor stratigraphic correlation between opposite sides may be explained by the strike-slip movement of a wrench fault having juxtaposed facies possessing dissimilar small-scale bedding characteristics.

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The Hill": An Unusual Glacial Feature In Schuylkill County

by
Duane D. Braun and Keith Springman
Geography and Earth Science Department
Bloomsburg State College

"The Hill" is a till-capped sand deposit located 1.7 mi northwest of Ringtown (west of Mahanoy City) on the north side of legislative route 53064 (northeast portion of Ashland 7½ ′ quadrangle) (Fig. 1). The deposit forms a knob that projects from the flank of Little Mountain into the valley of Trexler Run and lies 1.6 mi northeast of a low col that marks the drainage divide with Roaring Creek. Trexler Run, which makes a broad loop around "The Hill" has been displaced southward by the deposit where it has cut a relatively narrow, steep walled channel 40 feet into bedrock. The sand is mined by the owner, Daniel Grow of Ringtown.

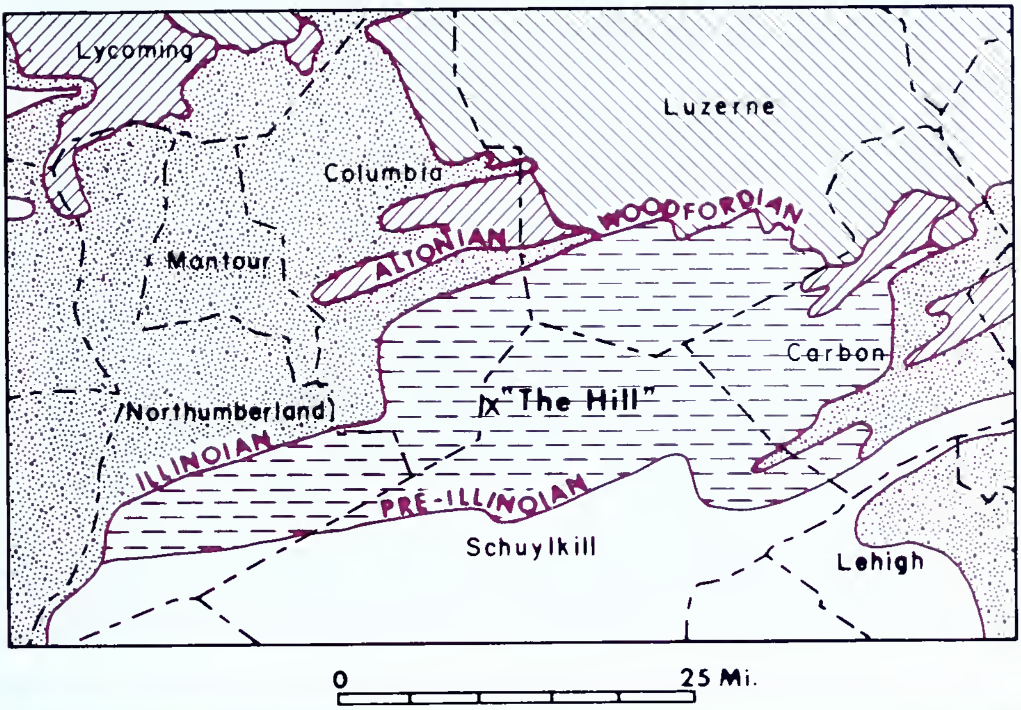

Figure 1. Map showing extent and age of glacial deposits in east central Pennsylvania. Woodfordian, Altonian, and Illinoian areas taken from 1980 Geologic Map of Pennsylvania. Pre-Illinoian area is from Leverett (1934).

The deposit comprises 3 to 6 ft of bouldery diamicton (till) overlying 33 to 36 ft of sand (Fig. 2). The diamicton is a moderately cohesive and unsorted mixture of clay to boulder-sized material. The matrix between clasts tends to be silty or sandy and is reddish brown in color, reflecting its derivation from the underlying red shale and sandstone of the Mauch Chunk Formation. Pebble-sized and larger clasts are angular to well rounded, commonly striated, and relatively unweathered to moderately weathered with weathering rinds a few millimeters thick. The larger clasts are dominantly sandstone and conglomerate derived from the Mauch Chunk, Pocono, and Pottsville Formations.

The sands are medium to very fine grained, yellowish brown and well stratified with prominent ripples, climbing ripples, and cross bedding. Anthracite grains form dark laminae and are also present as scattered pebble-sized and larger fragments. The upper 3 to 6 ft

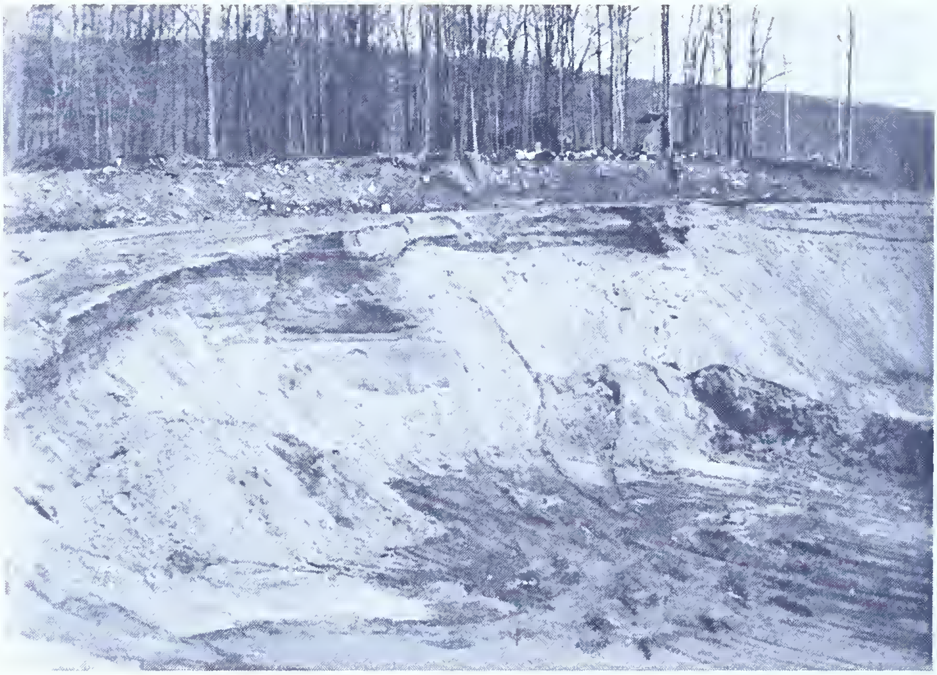

Figure 2. Till overlying kame delta sands; Little Mountain forms skyline.

of sand have been oxidized to a reddish yellow to black color. A few small-scale normal faults and reverse faults of a few millimeters to centimeter displacement are present. The fine-grained sands immediately under the diamicton are deformed into a series of folds or convolutions by unequal loading (load casting) of the diamicton upon the sands. Clast-rich portions of the diamicton tend to protrude downward into the underlying fine to very fine grained sands, in places producing vertical isoclinal folds in the sands.

"The Hill" is interpreted to be part of a kame delta that was deposited in a proglacial lake that formed when advancing ice blocked Trexler Run's eastward flow (Fig. 3). The lake spilled westward, as suggested by the attitude of the cross bedding, across a low col at an elevation of about 1200 ft into the Roaring Creek drainage (Fig. 3). The lack of coarse sand and larger grain sizes, the horizontality of the bedding, the presence of climbing ripples, and the fact that the top of the sand is 50 ft below the spillway elevation, indicate that the sands are probably the bottomsets at the distal edge of an originally much larger kame delta. A few rounded masses of diamicton as much as 1.5 ft in diameter occur within the upper 6 ft of the sands. The deformation of bedding beneath these masses suggests that they were dropped from ice rafts floating on the lake surface.

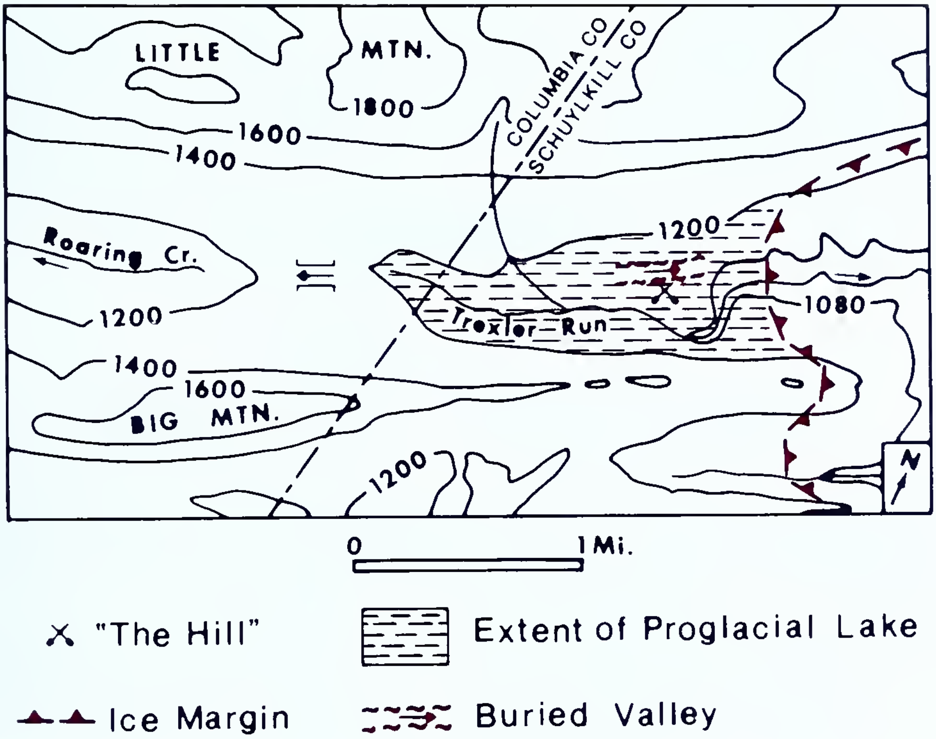

Figure 3. Map showing the position of the ice margin and the proglacial lake at the time the kame delta was being deposited.

The diamicton overlying the sands may have been deposited (1) directly from glacier ice that overrode the delta, (2) as a subaqueous debris flow from the nearby edge of the glacier, or (3) from basal melting of overriding but floating glacier ice. There is no conclusive evidence to prove or disprove any of these alternatives, but deposition directly from the glacier seems most probable.

This deposit lies beyond the limits of glaciation shown on the 1980 Geologic Map of Pennsylvania, but was included in an area of pre-Illinoian drift by Leverett (1934) (Fig. 1). The degree of weathering and soil development in the diamicton is similar to that of the Glen Brook till (Inners, 1981) which is considered early Wisconsinan (Altonian) in age. In contrast, the amount of erosion of the deposit, the deep incision of translocated Trexler Run, and the lack of other glacial deposits for several miles around the site are facts more consistant with an Illinoian age. More study is required before an age assignment can be made with confidence.

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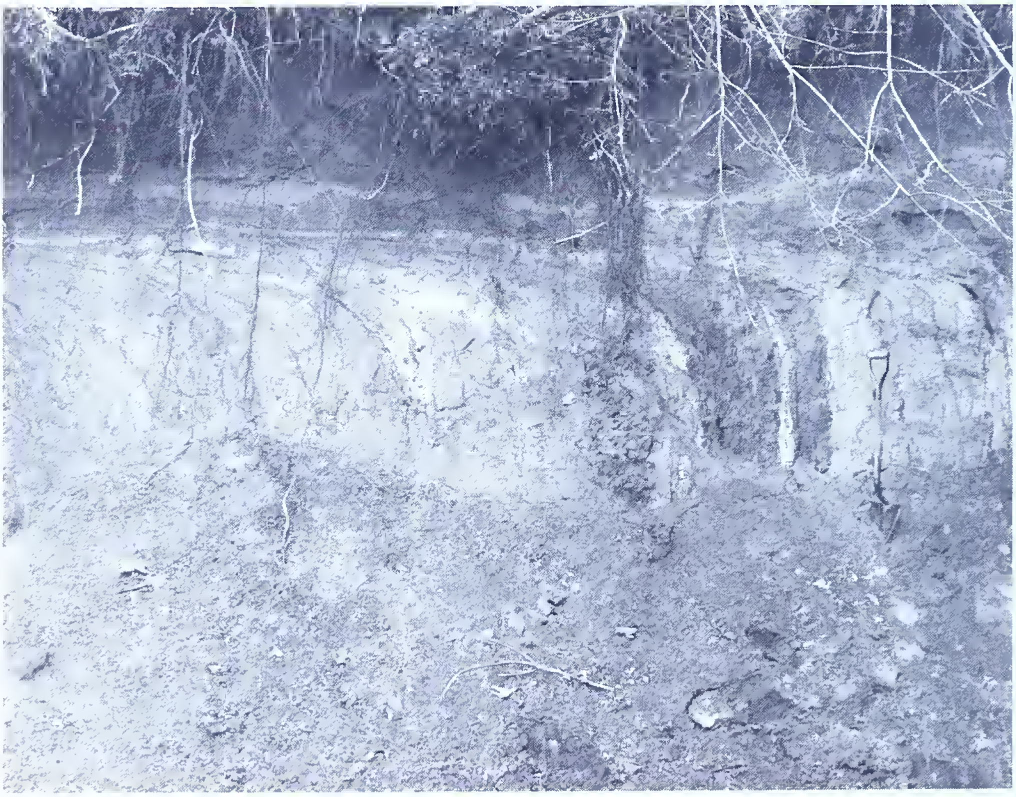
Watch out for the Creep

Zone of weathered gneiss showing effects of slow, down-slope movement due to gravity, a phenomenon known as creep. Where movement of weathered zone directly above the bedrock is minimal, the banding is vertical; where movement has been pronounced, the banding is nearly horizontal. The topographic slope is 4:1 or less than 15°. Such differential movement suggests the need for caution in planning foundations and interpreting geochemical soil surveys. The shovel in the photo is about 3 feet in length.



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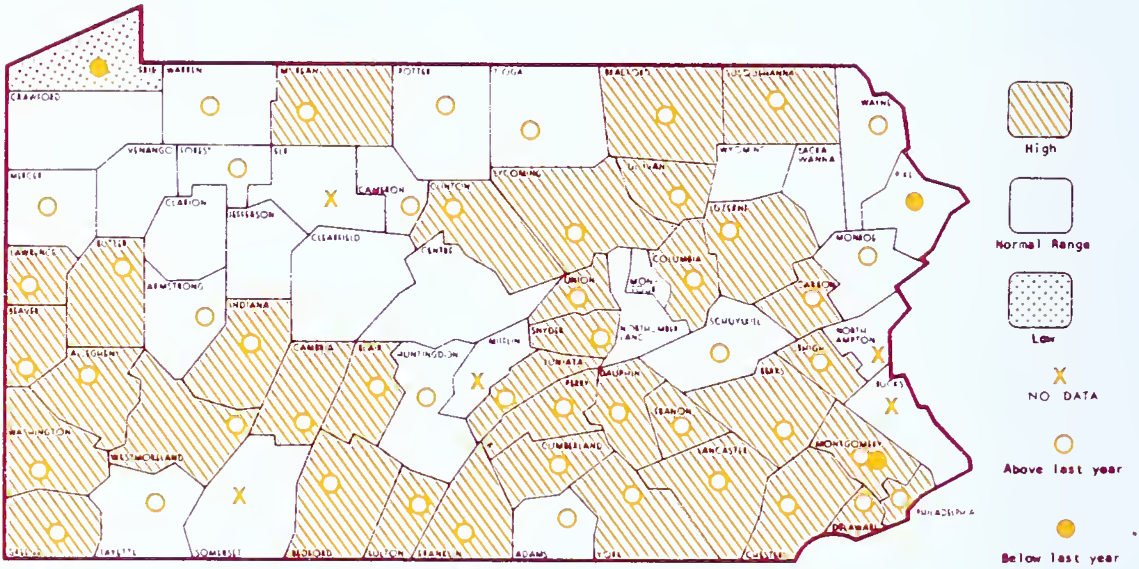

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ON THE COVER: Interbedded limestone and black shale of Salona Formation; conjugate folds cut by faults along U.S. Route 322, .5 miles west of Reedville, Mifflin County, PA. Photo courtesy of Rodger Faill.

PENNSYLVANIA GEOLOGY is published bimonthy by the Topographic and Geologic Survey, Pennsylvania Dept. of Environment Resources, Harrisburg, Pennsylvania, 17120.

Editor, Arthur A. Socolow; Associate Editor, Donald M. Hoskins.

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August 1983

FROM THE DESK
OF THE
STATE GEOLOGIST

A MISSING LINK IN NATIONAL SECURITY

When it comes to military preparedness for national security, our nation has traditionally accepted the costs as a fundamental obligation and has spent whatever is felt necessary to fulfill the security obligation.

The security of our nation, however, has components other than military. Those of us involved with geology recognize that there is a phase of security dealing with the availability of strategic minerals — those minerals without which our military machinery and industrial complex literally could not function or be built. Geologists are particularly conscious of the fact that many items on the list of strategic minerals are available wholly or largely from foreign sources only, many of questionable stability. Thus, we have a national security problem. We had a taste of that in 1973 when we faced the Arab oil embargo — but that was only a mild problem since our dependence on foreign oil was less than 50 percent. We face a far greater crisis where we are presently nearly totally dependent on foreign sources for chrome, manganese, nickel, tin, bauxite (aluminum) and many other lesser known minerals.

But unlike military security, however, our nation traditionally, and still today, depends primarily on the private sector to cope with its strategic minerals needs. Can you imagine our military security being dependent on private enterprise and undertaking only those ventures where a profit is assured!

Many who deal with minerals and recognize the extremely long lead time needed to explore, plan, finance, and develop the mines for strategic minerals in domestic and friendly areas believe that our government should recognize the security role of these strategic minerals and assume the responsibility to help develop them, just as it assumes the responsibility for military preparedness.

National security is hardly a debatable issue. The strategic mineral component of it deserves more attention and support than it has received. We still have the opportunity to take corrective action before a crisis arises.

Arthur A. Socolow

Trilobites Highlight A Collection of Fossils From Swatara Gap

by Jim Gerhart
Harrisburg, Pa.

During the last several decades, Ordovician shales and siltstones of the Martinsburg Formation at Swatara Gap have yielded a fascinating variety of well preserved marine fossils. A collection made by the author during the 1970's includes specimens representing seven invertebrate phyla and is highlighted by nine trilobite genera. This article briefly describes the location, geologic and depositional history, and fossil fauna of the Swatara Gap collecting site. In addition, the trilobite specimens in the collection are described.

The collection was assembled from rocks of the Martinsburg Formation which are exposed in a roadcut (Figure 1) along Interstate 81 about 1.9 miles north of the Lickdale exit in Lebanon County, just south of a bridge carrying the southbound lane. The same fossil-bearing strata are also exposed just northeast of the roadcut in an old borrow pit along Pa. Route 72, underneath the bridge carrying the northbound lane of I-81. Both outcrops are in the Indiantown Gap 7½-minute quadrangle. The fossiliferous rocks in

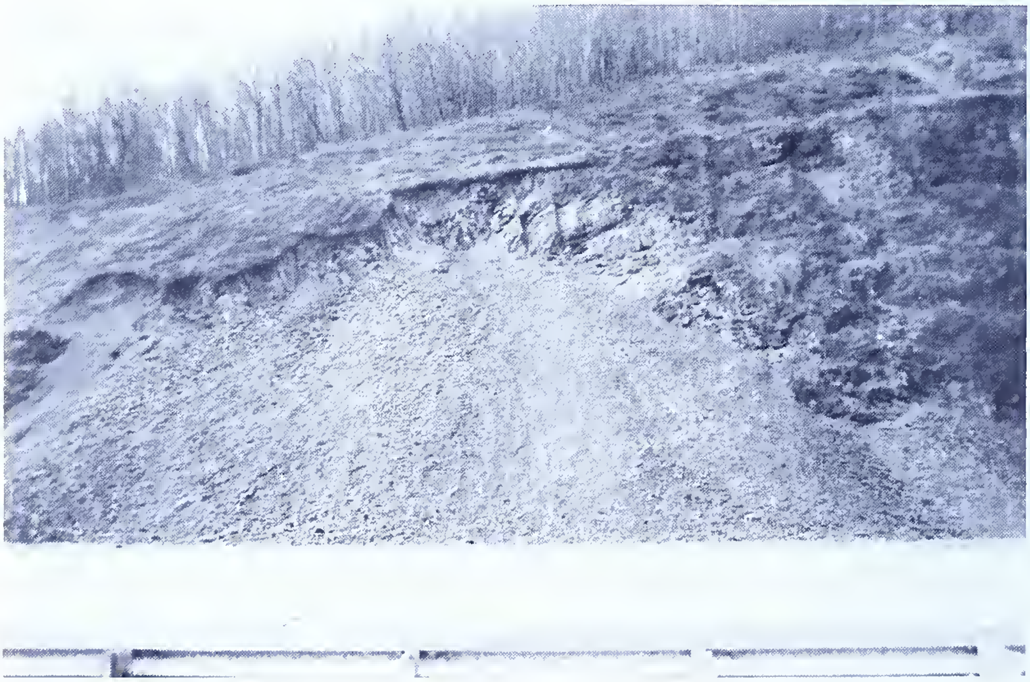


Figure 1. I-81 roadcut at Swatara Gap. Rock debris is the result of fossil collecting.

the roadcut are almost completely buried beneath rock debris caused by extensive collecting. Due to the danger posed by the encroachment of the debris onto the highway shoulder, collecting from the roadcut is no longer permitted. Fortunately, collecting is still possible in the borrow pit; however, it is hampered by an equally thick blanket of rock debris.

In Ordovician time (about 440 million years ago), a vast sea covered the present location of the Appalachian Mountains. The area now known as Swatara Gap was situated in a shallow portion of that sea. Where Swatara Gap is today, predominantly fine-grained sediments accumulated, eventually to become shales and siltstones of the upper Martinsburg Formation. Later, the originally horizontal beds at Swatara Gap were tilted to the northwest until they stood nearly vertically. The edges of some of these beds are now exposed in the I-81 roadcut.

The environment of deposition of the fine-grained sediments that formed the shales in the roadcut can be inferred from the fossils preserved in them. The invertebrate phyla found at Swatara Gap indicate a warm, shallow, sunlit, marine enviroment. The diversity of the fauna indicates an abundance of food. The fact that many of the fossils are articulated (skeletal parts still connected) indicates that there was generally a minimum of turbulence in the water. The degree of articulation also points to a fairly rapid burial by sediment influx. The fortuitous combination of fine-grained sediments, calm waters, and rapid burial resulted in the preservation of many of the more delicate structures of the organisms. These include spines and compound eyes of trilobites, spines of stelleroids (starfish), calyxes, ambulacra, and pinnules of crinoids, and sponge spicules.

Interbedded with the shales are numerous thin siltstone lenses. They are probably the result of occasional currents which carried coarser sediments farther from shore than usual. Commonly, these siltstone lenses contain many densely-packed fossils, indicating that the currents transported and also concentrated the remains of many organisms. Turbulence during transportation left many of the fossils in the siltstone lenses disarticulated. Many of the siltstone lenses contain rich concentrations of the rarer fossils.

All the fossils are external molds of the original hard parts of the organisms. When the organisms died, their soft parts (tissue, muscles, membranes) were either eaten by other organisms or decomposed. The remaining shells and skeletal materials were buried by fine-grained sediments which were molded to the contours of the remains. Subsequently, the sediments containing the remains were compacted and cemented and became rock. The original hard parts eventually dissolved, resulting in external molds, or rock voids bearing the impressions of the hard parts on their walls. Recently, ground water has deposited an iron-oxide coating on the walls of many of these voids, imparting a distinctive orange coloring.

Wright and others (1977) recognized at least 82 genera representing nine major invertebrate phyla. The major fossil types at Swatara Gap (with the number of recognized genera in parentheses) are brachiopods (15), trilobites (10), crinoids (9), bivalves (9), stelleroids (8), bryozoa (7), graptolites (5), ostracodes (4), gastropods (3), and cephalopods (3). Included in the author's collection are specimens of nearly all the genera from seven of the nine phyla described by Wright and others (1977).

Trilobites are one of the more interesting types of fossils found at Swatara Gap. Now long extinct, trilobites were bottom-dwelling arthropods similar in appearance to small horseshoe crabs. Their exoskeletons consisted of three parts. The cephalon, or head, consisted of a raised central portion, the glabella, which was flanked by a pair of kidney-shaped eyes. Commonly, the outer border of the cephalon was terminated in short to relatively long extensions called genal spines. The thorax, or body, was a series of connected segments. The pygidium, or tail, was the rounded or slightly pointed posterior section of the exoskeleton.

Nine trilobite genera are included in the author's collection. These genera and estimates of their relative abundance at Swatara Gap are given in the following list:

Acidaspis i
Cryptolithus a
Diacanthaspis r
Flexicalymene c
Isotelus i
Mesotaphraspis r
Platylichas r
Pterygometopus i
Triarthrus c

abundance codes
a always found
c commonly found
i infrequently found
r rarely found

Brief descriptions of the trilobites in the collection follow, accompanied by photographs of some of the better specimens.

Acidaspis: The collection includes two nearly complete, articulated specimens and six partial specimens. They range in length from about 0.5 to 1.3 inches. Most of the specimens are from siltstone lenses. Cephalic, thoracic, and pygidial border spines are preserved on the articulated specimen in Figure 2.

Cryptolithus: Many complete, articulated specimens and many partial specimens of this ubiquitous trilobite are included in the collection. They all exhibit an expanded glabella and a broad cephalic fringe with concentric rows of small pits. They range in length from about 0.2 to 0.8 inches.

Diacanthaspis: The collection contains only one specimen of this rare trilobite. It is articulated but rather poorly preserved and is only about 0.2 inches long. The cephalon and most of the thorax are indistinct, but many thoracic and pygidial border spines are visible. Furthermore, and most important for identification purposes, two relatively long spines emanate from the center of the base of the cephalon.

Flexicalymene: Eleven complete, articulated specimens of this common trilobite were collected. They range in length from about 0.3 to 1.5 inches. One is partially rolled. Figure 3 shows a specimen whose pygidium became separated from its thorax, but was transported only about 0.1 inch away from the thorax before burial.

Figure 3. *Flexicalymene* (x2.5)

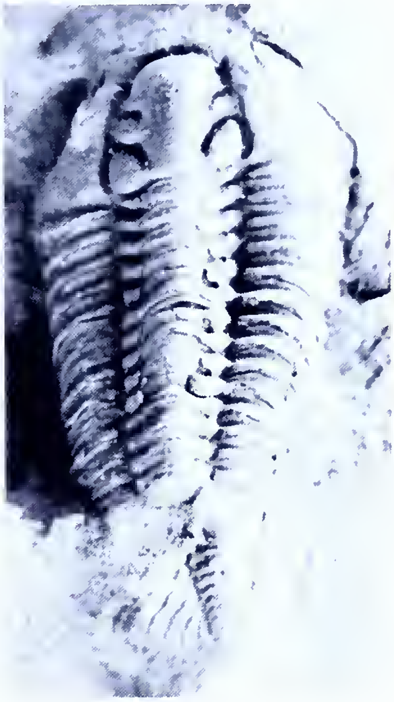


Figure 2. *Acidaspis* (x2.5)

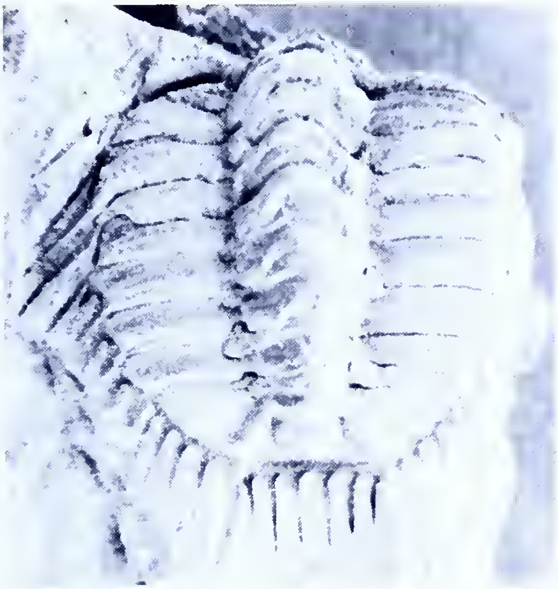


Figure 4. *Isotelus* (x1)

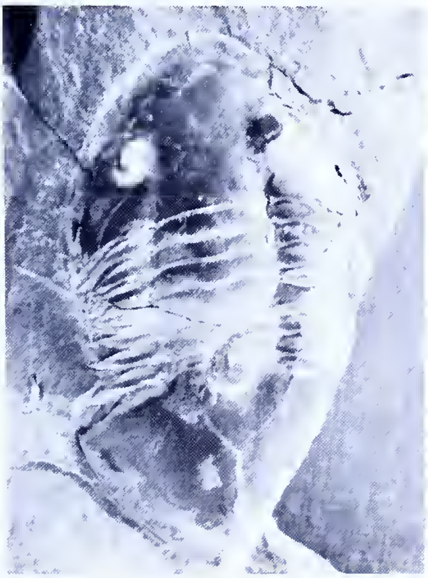
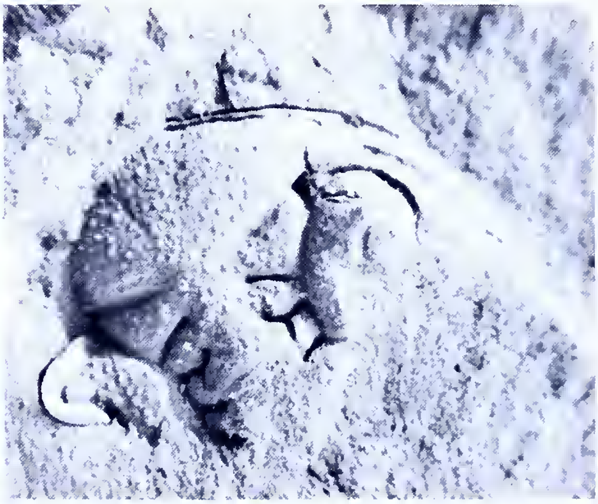


Figure 5. *Pterygometopus* (x3)



Isotelus: Included in the collection are four nearly complete, articulated specimens and three partial specimens of this genus. They range from 2 to 3 inches in length and most of them, including the specimen in Figure 4, have well preserved compound eyes containing hundreds of tiny hexagonal lenses.

Mesotaphraspis: This relatively rare trilobite is represented by five articulated specimens ranging in length from about 0.1 to 0.3 inches. Two of the five specimens are on one 2-inch slab. Relatively long genal spines and a spine protruding from the center of one thoracic segment are helpful in distinguishing this small trilobite from *Proetus,* which is the only known Swatara Gap genus not included in the author's collection.

Platylichas: A single glabella of this rare trilobite is all that was collected. Based on the size of the glabella, the complete trilobite was probably about 0.5 inches long.

Pterygometopus: No complete specimens of this genus are included in the collection; however, ten cephalons and two pygidia were found. Judging from the size of these two parts of the exoskeleton, the complete trilobites were probably about 1 inch long. Both pygidia and all but two of the cephalons were collected from siltstone lenses. Each of the ten cephalons is characterized by a distinctive mushrooming glabella, raised eyes, and long genal spines (Figure 5).

Triarthrus: This rather common trilobite is represented in the collection by two incomplete, articulated specimens and five glabellas. The articulated specimens have narrow exoskeletons less than 1 inch long. Complete specimens of this genus are rare.

This collection, currently in the author's possession, is available for study to any interested persons. In the near future, many of the better Swatara Gap specimens, [as well as specimens from other central and southeastern Pennsylvania collecting sites], will be donated to the William Penn Memorial Museum in Harrisburg.

REFERENCE

Wright, T. O., Garwood, S. M., and Derstler, K. (1977), The age of the Martinsburg Formation at Swatara Gap, Pennsylvania, Pa. Acad. Sci. Proc., v. 51, p. 85-87.

Coal Cropline Maps Placed On Open File

The Pennsylvania Geological Survey is placing on open file a set of topographic quadrangle maps (scale 1:24,000) covering Greene and Washington Counties on which have been plotted the outcrop lines of the major coal seams as well as the boundaries of the known mined out areas; there is a separate map for each coal seam.

These maps, which eventually will be published, are available for examination at the Survey, Rm. 907, Executive House, 101 S. Second St., Harrisburg, Monday through Friday 8:00 a.m. to 4:00 p.m.

Geological Research In Pennsylvania 1983

Introduction

This publication is the twenty sixth annual report on Geological Research and Publications in Pennsylvania. This is an attempt to list all current geologic research in Pennsylvania and *includes persons and projects other than those of the Pennsylvania Geological Survey*. Because of the large number of projects reported to us, we exercise editorial license to reduce the description of the research projects to fit out available space.

We have also attempted to determine an anticipated completion date (ACD) for each project. The anticipated completion date is the estimate of the date when the author will complete his report; additional time should be anticipated until the report is published. If you wish more information on a project described herein, please write directly to the author; most of these projects will *not* be published by the Pennsylvania Geological Survey inasmuch as most are not Survey sponsored projects.

The listings are grouped into major categories of research to facilitate your search for information on a particular subject. Reports published are listed alphabetically by author.

As with all compilations, there may be omissions; this is unintentional. Additional copies of this report may be obtained by writing to the Bureau of Topographic and Geologic Survey, Department of Environmental Resources, P.O. Box 2357, Harrisburg, Pennsylvania 17120.

Areal Geology

W. E. DAVIES and **GREGORY OHLMACHER,** U.S. Geol. Survey. Geology and Engineering Geology of the Cumberland 1:100,000 Map Area. Field mapping and compilation have been completed. A continuous geologic profile along the Potomac River has been made and will be included as a structural profile at 1:2,400 scale with expanded scale at 1:600 where the structure is complex. The profile extends across the map area from North Mountain to Big Savage Mountain. ACD: Aug. 1983.

N. K. FLINT and **TIMOTHY KUNTZ,** Univ. of Pitt. A Study of the Vanport Limestone in Elk Co. ACD: May 1984.

J. W. HEAD, Brown Univ. Analysis of Shuttle Imaging Radar-A Images of the Appalachians in Pa. Analysis of Shuttle Imaging Radar-A images and comparison to Seasat Radar and Landsat images to examine the utility of radar images in geologic mapping in folded mountain belts.

J. D. INNERS, Pa. Geol. Survey. Geology and Mineral Resources of the Allenwood and Milton Quads., Northumberland and Union Cos., Pa. ACD: 1984.

D. B. MacLACHLAN, Pa. State Univ., and **HENRY SCHASSE,** Washington Dept. Natural Resources. Geology and Coal Resources of the Conyngham Quad., Luzerne and Schuylkill Cos., Pa. Areal mapping of general geology by Schasse is completed. Coal crop maps and coal resource calculations are in progress. ACD: 1983.

H. A. POHN, A. R. TAYLOR, and **T. L. PURDY,** U.S. Geol. Survey, **G. W. COLTON,** Ala. Geol. Survey, and **G. H. CROWL,** Ohio Wesleyan Univ. Geology and Mineral Resources of the Jersey Shore Quad., Lycoming and Clinton Cos., Pa. Bedrock and surficial maps and report are complete and technical review at the U.S. Geol. Survey is finished. The atlas is in review at the Pa. Geol. Survey. ACD: Late 1983.

W. D. SEVON and **T. M. BERG,** Pa. Geol. Survey, and **ROBIN ABEL,** Defense Mapping Agency. Lithologic Map of Pa. This 1:500,000 derivative of the 1980 State Geologic Map will show 18 different rock units, and will not have categories of geologic time. ACD: Late 1983.

W. D. SEVON and **T. M. BERG,** Pa. Geol. Survey, **L. D. SCHULTZ,** Weston Geophysical Corp., and **G. H. CROWL,** Ohio Wesleyan Univ. Geology and Mineral Resources of Pike Co., Pa. ACD: Fall 1983.

A. N. WARD, JR., Slippery Rock Univ. Mapping (bedrock) of the Titusville N and S Quads. Mapping in progress. ACD: 1986.

J. H. WAY, Pa. Geol. Survey. Geology and Mineral Resources of the Washingtonville and Millville Quads., Columbia, Montour, and Northumberland Cos., Pa. Geologic mapping of bedrock and surficial deposits, sampling materials with possible economic potential, and describing environmental and engineering characteristics of all geologic units within the area. ACD: 1983.

Economic Geology

K. D. ABEL, C. D. LAUGHREY, and **J. A. HARPER,** Pa. Geol. Survey. Oil and Gas Geology of Southwestern Pa. ACD: Dec. 1983.

S. W. BERKHEISER, JR., Pa. Geol. Survey. Reconnaissance Study of High-Purity Silica Deposits in Pa. Thirty-two sedimentary and igneous samples of high-purity (+97%) silica sources are being analyzed for chemical and physical characteristics. Magnetic as well as acid beneficiation tests have been run on these samples. Preliminary chemical analyses of unbeneficiated sedimentary samples yield lows of 210 ppm for Fe_2O_3 and 2400 ppm for Al_2O_3. ACD: 1983.

S. W. BERKHEISER, JR., Pa. Geol. Survey. Reconnaissance Study of Strata-Bound Barite Occurrences in Berks Co., Pa. Float mapping of about 6 square miles (15 km^2) has identified fetid, dark-gray, nodular-like barite mineralization and host rock relationships. Interpretations of paragenesis, age, and exploration geochemistry are presented. Reconnaissance geologic maps are included which contrast with previously published versions. ACD: 1983.

S. W. BERKHEISER, JR., and **J. H. BARNES,** Pa. Geol. Survey. Directory of the Non-Fuel Mineral Producers in Pa. This compilation will provide a directory of the approximately ½ billion dollar non-fuel mineral industry in Pa. Mineral commodity, county, and producer listings are proposed which would include individual addresses, telephone numbers, list of products, mines, producing formations, and lithologies. ACD: 1984.

A. D. GLOVER, C. H. DODGE, J. R. SHAULIS, and **V. W. SKEMA,** Pa. Geol. Survey. Coal Resources of Western Pa. Data for coal-bearing strata in portions of Fayette and Westmoreland Counties have been entered into the National Coal Resources Data System (NCRDS) computer. Information for the remainder of Fayette and Westmoreland Counties, and for Cambria, Blair, and Butler Counties is currently being assembled and prepared for entry into the system. This program will result in computer-generated resource maps for Western Pa.

S. T. PEES, Samuel T. Pees & Associates, **C. R. BURGCHARDT,** Univ. of Pitt. at Bradford, and **T. JENNEY,** Samuel T. Pees & Associates. Production History of an Average Medina Gas Well Derived from a Multi-Well Model in Northwest Pa. [Crawford, Erie, and Mercer Cos. Emphasis and model are directed primarily to the

Conneaut field complex in Crawford Co]. Actual records from initial flow (IPF) to final abandonment of 29 wells assembled by computer into an average Medina well life history. Depicted by graphs. Short term decline curves for several areas. Grimsby, Cabot Head, and Whirlpool commingled. ACD: Aug. 1983.

S. T. PEES, Samuel T. Pees & Associates, **P. LUCE,** Mansfield Univ. of Pa., and **T. JENNEY,** Samuel T. Pees & Associates. Early Sedimentary Iron Mining in Southwestern Crawford Co., Pa. Subject applies to history of geology and mining but our current research on stratigraphy, sedimentation, and chemical analysis of these minor Lower Mississippian iron-rich beds is incorporated in the study. ACD: Mar. 1984.

R. C. SMITH, II, and **J. H. BARNES,** Pa. Geol. Survey. Geologic and Mineralogic Interpretation of Gamma-Ray Reconnaissance Data for the Reading Prong, Eastern Pa. [portions of Berks, Bucks, Lehigh, and Northampton Cos.] Data on U and Th occurrences are being interpreted. Occurrences are being grouped by U/Th ratios and host rock composition. Titanite separates from a group of skarn deposits have been analyzed. ACD: 1983.

IRA STAR and **D. P. GOLD,** Pa. State Univ. Gas Reserves in the Medina Group of NW Pa. as Related to Fracture Porosity and Stratigraphic Control. High gas reserves were found between Meadville and Franklin, Pa., along French Creek. This feature appears to have influenced deposition of the Medina Group. Lineament density (from low-altitude panchromatic photographs) orientations parallel bedrock lithologies. Stratigraphic control is significant in the location and shape of hydrocarbon pools. ACD: May 27, 1983.

R. W. STINGELIN, Resource Technologies Corp. Defining the Anthracite Resources of Northeastern Pa. Publication delayed due to transfer of contract from U.S. Dept. of Energy to U.S. Bureau of Mines. ACD: Aug. 1983.

Engineering Geology

R. W. BRUHN, S. R. MICHALSKI, and **L. J. WINSCHEL,** GAI Consultants, Inc. Engineering Analysis and Evaluation of Centralia Mine Fire. This study is to review all existing data and to develop new information whereby plans will be developed to abate the spread of the 20-year-old mine fire.

W. E. DAVIES, JOHN POMEROY, WILLIAM OUTERBRIDGE, STEPHEN OBERMEIER, and **GREGORY OHLMACHER,** U.S. Geol. Survey. Slope Movement in the Appalachian Plateaus. This report will be a professional paper of the U.S. Geol. Survey summarizing the results of observations and mapping of landslides in the Appalachian Plateaus since 1973. ACD: July 1983.

J. V. HAMEL, Hamel Geotechnical Consultants, **H. M. FAUSOLD** and **C. E. STEVENSON,** Pbg. District, U.S. Army Corps of Engineers. Bank Instability on the Monongahela River, Pa. Bank instability is being investigated at six sites along the Monongahela River 92 to 103 km upstream from Pittsburgh Bank degradation is a geotechnical process involving complex interactions in bank soils. ACD: Aug. 1983.

Environmental Geology

N. K. FLINT and **ROBERT WEISS,** Univ. of Pitt. Landslide Hazards in Penn Hills Twp., Allegheny Co. ACD: May 1984.

W. B. WHITE, B. E. SCHEETZ, and **G. D. COX,** Pa. State Univ. Geochemical Models for the Behavior of Heavy Metals in Chemical Waste Dumps. Analysis of the mineralogy of the products in chemical waste dumps provide the source term from which rates of release of heavy metals are estimated by geochemical models. ACD: Aug. 1983.

J. P. WILSHUSEN and **H. L. DELANO,** Pa. Geol. Survey. Landslide Susceptibility in the Williamsport 1° x 2° Map Area, North-Central Pa. A landslide inventory is underway with the compilation of occurrences on the 128 7½-minute quadrangles that comprise the Williamsport 1° x 2° map area. Landslides are related to geology, soils, drainage, and slope with select areas chosen for detailed analysis to establish slope stability characteristics of the region. ACD: Apr. 1984.

General Geology

WILLIAM KREIGER, Pa. State Univ., York Campus. Geology and Petrology of Bunker Hills Igneous Rocks [Bunker Hills, Lebanon

Co., about 4 miles north of the City of Lebanon in Swatara Twp.]. Whole-rock chemical analysis of intrusive and extrusive igneous rock samples in this area has been completed and optical studies of rock thin sections are presently in progress. ACD: Continuing.

P. T. LYTTLE and **JACK EPSTEIN,** U.S. Geol. Survey. Newark 2° Quad. Project. 1983 will see the completion, and submittal for review of the Newark 2° quadrangle that contains portions of eastern Pa., northern N.J., and southern N.Y. ACD: June 1983.

Geochemistry

A. W. ROSE and **E. P. DRESEL,** Pa. State Univ. Chemical Composition of Oil and Gas Well Brines from Western Pa. Forty samples from wells in central and northwestern Pennsylvania are being analyzed, with emphasis on heavy metals in high-salinity brines. Brines are near neutral, but high Fe (100-500 ppm) results in acid pH on oxidation. Ba is up to 4000 ppm. ACD: Dec. 1983.

A. W. ROSE and **CINDY PAGE,** Pa. State Univ. Oxidation State and $\delta^{18}O$ Values of Triassic Sediments Near Cornwall-Type Magnetite Deposits. The Fe^{3+}/Fe^{2+} δ ratio and $\delta^{18}O$ of quartz and clays from Triassic sediments near Cornwall are being determined to test the hypothesis that circulation of heated sedimentary brines adjacent to diabase formed the magnetite ores. ACD: Dec. 1983.

Geomorphology

P. D. KNUTH, Edinboro Univ. of Pa./Consultant, Dept. of Enviromental Resources/Principal Inv., Coastal Research Associates, and **WILLIAM BURT, MARK FLOOD,** and **WILLIAM NAGEL,** Coastal Research Associates. Geotechnical Investigation of the Coastal Bluffs of Erie Co., Pa. The project is designed to determine recession states, volumetric losses, and site physiography of the bluffs. The work is being funded by the Coastal Zone Management Program and funded through the Pa. Dept. of Environmental Resources, Bureau of Water Resources Management, Division of Coastal Zone Management. ACD: Summer 1983.

NOEL POTTER, JR., Dickinson Coll. Distribution and Origin of

Gravels and Colluvium in Cumberland and Franklin Cos. Continuation of mapping of thick gravels along the flanks of South and Blue Mountains, and their relation to residuum weathered from underlying carbonates and to alluvial terraces along Conodoguinet, Yellow Breeches, and Conococheague Creeks. ACD: Continuing.

E. L. WHITE and **W. B. WHITE,** Pa. State Univ. Quantitative Geomorphology of the Appalachian Karst. Description, measurement, and modeling of caves and karst surface from Pa. to Ala. and their interpretation as part of drainage basin evolution and Pleistocene history. ACD: 1990 (?).

W. B. WHITE, Pa. State Univ. Pa. Cave Survey. The object is a complete description of Pennsylvania's caves. With completion of Perry and Mifflin County surveys, current effort is on Bedford County and on the counties of the West Branch of the Susquehanna. ACD: Late 1983(?).

Geophysics

D. D. BRAUN, Bloomsburg Univ. of Pa., and **J. D. INNERS,** Pa. Geol. Survey. Geophysical Investigations of the Orangeville "Umlaufberg" and Ten-Mile Run Valley, Columbia Co., Pa. ACD: 1984.

Glacial Geology

J. E. BAXTER, and **T. W. GARDNER,** Pa. State Univ. Quaternary Geology of the West Branch of the Susquehanna River and Bald Eagle Valleys Near Lock Haven, Pa. Detailed surficial geologic mapping of the Lock Haven, Beech Creek, and Mill Hall 7½-minute quadrangles has determined the extent of pre-Wisconsinan glaciation in the West Branch of the Susquehanna River valley. A pre-Wisconsinan glacial maximum in the vicinity of Lock Haven was followed by a period of stable base level controlled by the elevation of glacial drift in the valley. ACD: Apr. 1983.

G. H. CROWL, Ohio Wesleyan Univ., and **W. D. SEVON,** Pa. Geol. Survey. Supposed Glacial Drift East of Mifflintown, Pa. The 1980 geologic map of Pennsylvania shows a long extension of the Illinoian ice border southwest from Richfield to Mifflintown. Field work in 1982 between Richfield and McAllisterville showed no glacial drift, so the diamicton at Mifflinville is probably colluvium.

Hydrology

A. E. BECHER, U.S. Geol. Survey. Ground-Water Resources In and Near the Anthracite Basins of Schuylkill and Adjacent Counties, Pa. Define areas of ground-water contamination by anthracite mining; evaluate potential for contamination of adjacent aquifers by future mining and expanded development of ground water. Document the availability and quality of water from all aquifers. ACD: June 1983.

A. E. BECHER, U.S. Geol. Survey. Ground-Water Resources of Cambrian and Ordovician Carbonate Rocks in the Valley and Ridge Province of Pa. Describe and define quantitatively the ground-water resources of Cambrian and Ordovician carbonate rocks in the Appalachian Mountain section of the valley and Ridge province in Pennsylvania, estimate the effects of below-normal recharge, and determine the extent and degree of nitrate contamination of ground water. ACD: June 1986.

D. K. DAVIS, U.S. Geol. Survey. Geology and Ground-Water Resources of Pike County, Pa. ACD: Sept. 30, 1983.

D. K. FISHEL and **J. E. RICHARDSON,** U.S. Geol. Survey. Preliminary Results of the Preimpoundment Water-Quality Study of the Swatara Creek Reservoir, Pa. [Swatara Creek watershed above Inwood, Pa.]. The Pa. Dept. of Environmental Resources, Bureau of State Parks, plans to build a multi-purpose reservoir in Swatara State Park in south-central Pennsylvania. The proposed impoundment is to be built downstream from areas extensively mined for anthracite. Large amounts of culm and sediments have been and continue to be transported by Swatara Creek from abandoned and active mines, culm piles, and breaker plants to the planned impoundment site. ACD: Mar. 1985.

J. M. GERHART, U.S. Geol. Survey. Development of Method to Determine Depth of Casing for Oil and Gas Wells in Western Pa. The objective is to develop a method to determine the optimum amount of casing for new oil and gas wells so that casing length and ground-water contamination by saline water are minimized. ACD: 1984.

J. M. GERHART, U.S. Geol. Survey, and **G. J. LAZORCHICK,** Susquehanna River Basin Comm. Development and Use of a Digital Ground-Water Flow Model of the Lower Susquehanna River Basin, Pa. and Md. The project consists of the development of a three-dimensional ground-water flow model in secondary-permeability terrane. The calibrated model has been used to evaluate the ground-water resources of the lower basin. ACD: 1983.

J. M. GERHART, U.S. Geol. Survey, and **G. J. LAZORCHICK,** Susquehanna River Basin Comm. Simulation of Unconfined Ground-Water Flow in Secondary-Permeability Terrane in Parts of Lancaster and Berks Cos., Pa. The carbonate aquifers of the Conestoga Valley have been modeled. The effects on ground-water levels and baseflow to streams of various hypothetical scenarios of withdrawals and drought have been simulated. ACD: 1983.

T. A. McELROY, Pa. Geol. Survey. Groundwater Resources of Cambria Co. The project will provide a description and inventory of groundwater resources in Cambria Co. Two adjacent basins, one unmined, the other extensively strip mined, have been selected to determine if mining has an impact on hydrologic budgets. ACD: June 1984.

T. A. McELROY, Pa. Geol. Survey. Groundwater Resources of Fayette Co. The project will provide a description and inventory of groundwater resources in Fayette Co. The data gathered indicate that AMD generated in deep mines does not have a major impact on groundwater in undisturbed rock adjacent to the mines. Completion has been delayed by mapping of eastern Fayette Co. ACD: Fall 1983.

G. N. PAULACHOK, U.S. Geol. Survey. Ground-Water Resources of Delaware Co., Pa. Well inventory program is in progress and 400 of 500 identified sites have been visited. Data on water level, quality, and usage are being collected and site suitability for subsequent sampling and geophysical logging is being evaluated. ACD: 1984.

G. N. PAULACHOK, U.S. Geol. Survey. Water Resources of the Oley Valley, Berks Co., Pa. Data-collection program concluded successfully in Dec. 1982. Water budget computation and water table maps are in preparation. Analyses of samples from 30 sites indicate that contamination by nitrate and bacteria are the most common water-quality problems. ACD: Sept. 1983.

D. W. ROYER, Pa. Geol. Survey. Summary Groundwater Resources of Perry Co., Pa. ACD: Aug. 1983.

R. A. SLOTO, U.S. Geol. Survey. Effects of Urbanization on the Water Resources of Eastern Chester Co., Pa. ACD: Sept. 1985.

J. D. STONER, D. W. WILLIAMS, U.S. Geol. Survey, and others, U.S. Geol. Survey and Pa. Geol. Survey. Water Resources of Greene Co., Pa.-Appalachian Coal Basin. Report in review process.

D. R. WILLIAMS and **T. F. BUCKWALTER,** U.S. Geol. Survey, and others, U.S. Geol. Survey and Pa. Geol. Survey. Appraisal of Water Resources of Washington Co., Pa. This study will evaluate the water resources of the county, with emphasis on the ground-water hydrology in both mined and unmined areas. To date, about 30 wells have been inventoried and 5 stream gaging stations have been installed to monitor surface-water flow. ACD: Mar. 1986.

J. H. WILLIAMS, U.S. Geol. Survey, **R. R. PARIZEK,** Pa. State Univ., **ROGER HORNBERGER,** Pa. Dept. of Enviromental Resources, Bureau of Mining and Reclamation, and **KENN PATTISON,** U.S. Geol. Survey. Evaluation of the Surficial Application of Limestone Quarry Waste in the Abatement of Acidic Drainage from a Coal Strip-Mine Site, Clarion Co., Pa. ACD: June 1986.

J. H. WILLIAMS, U.S. Geol. Survey, and **L. E. TAYLOR** and **W. D. SEVON,** Pa. Geol. Survey. Hydrogeology of the Glaciated Valleys of the Susquehanna River Basin, Appalachian Plateaus Province, Pa. ACD: 1986.

Paleontology

T. M. BERG, Pa. Geol. Survey, and **JANE GRAY,** Univ. of Ore. Identification of the Marine-Nonmarine Boundary in the Trimmers Rock-Catskill Succession of NE Pa. Earlier research by R. E. Thoms and T. M. Berg pointed to a fluvial origin for the Towamensing Member of the Catskill. To further elucidate the Towamensing's depositional environment, Berg collected several shales, and these are being examined by Gray. To date, they have yielded only spores; no acritarchs or chitinozoans have been discovered.

P. S. BOYER, Fairleigh Dickinson Univ. Scolecodonts from Silurian and Devonian Carbonates of Eastern Pa. [Monroe Co]. ACD: 1985.

R. D. L. FULTON, Bucks Co. Community Coll. Middle Devonian Crinoids of NE Pa. [Carbon and Monroe Cos.] ACD: 1984.

J. A. HARPER, Pa. Geol. Survey. Carboniferous Corals of SW Pa. This project is part of a comprehensive study of SW Pa. Permo-Carboniferous faunas and floras in advance of completing a fossil collecting guide for the area. The corals, most of which were previously assigned to *Lophophyllidium proliferum,* are badly in need of revision. Most, if not all specimens, are expected to be assigned to other genera and species. ACD: Aug. 1983.

D. M. HOSKINS, J. D. INNERS, and **J. A. HARPER,** Pa. Geol. Survey. Fossil Collecting in Pa. Complete revision of General Geology Report 40. ACD: 1983.

W. F. KLOSE II, Paleontological Research Inst. Contributions to the Pennsylvanian Age Flora and Fauna of the Anthracite and Semi-Anthracite Coal Fields of NE Pa. Collection of Pennsylvania age flora and fauna with deposition of prepared specimens in the William Penn Memorial Museum, Harrisburg. ACD: Ongoing.

W. F. KLOSE II, Paleontological Research Inst. Fossil Flora and Fauna of the Ross Anthracite in the Northern Anthracite Basin, Pa. Specimens from the Larksville mine fire and Loree Colliery, Larksville, Pa., and Alden Mountain, Glen Alden, Pa., have been collected and prepared for study and illustration. ACD: July 1984.

G. R. McGHEE, JR., Rutgers Univ., and **R. G. SUTTON,** Univ. of Rochester. Late Devonian Marine Ecology and Zoogeography [along the Allegheny Front across the entire state and in NW Pa.]. The research project concerns the marine ecology and zoogeographical distribution patterns of marine animals which existed during the Late Devonian, and the response of those animals to the collapse of the ecosystem which occurred during the end of the Frasnian Epoch. ACD: Open ended.

W. A. OLIVER, JR., and **J. M. BERDAN,** U.S. Geol. Survey. Uppermost Silurian-Lower Devonian Corals and Ostracodes of the Central Appalachians [NY to VA]. Pennsylvania part of project is a study of the systematics and distribution (stratigraphic and geographic) of corals and ostracodes in the Keyser, Decker, and Helderberg Limestones. ACD: 1985.

R. A. REILLY, Univ. of Del. Organism-Substrate Analysis of the Onondaga Group in South Central Pa. The paleoecology of the Onondaga Group will be studied to relate certain animals to specific sediment types, and to create a three-dimensional paleoenvironmental model that exhibits the life habitats of the individual organism. ACD: June 1984.

P. K. STROTHER and **CECILIA LENK,** Dickinson Coll. Plant Remains from a Cretaceous Lignite in Southern Pa. Lignite from the spoil pile at Pond Bank near Chambersburg contains pollen, spores, cuticle, wood fragments, and small seeds. A determination of the botanical affinities will enable a climatic reconstruction of this late Cretaceous deposit. ACD: Late 1983.

ALFRED TRAVERSE and **NORMA JOHNSON,** Pa. State Univ. and **P. K. STROTHER,** Dickinson Coll. Microfossil Evidence for the Earliest Land Plants in Lower Silurian and Upper Ordovician Rocks of Pa. [at present studies are concentrating on Tuscarora outcrop near Mill Hall]. This work continues studies of Strother and Traverse of very primitive plant microfossils in Tuscarora shales at various locations in central Pa. A large variety of spores, spore-like bodies, conducting tubes and cuticle-like sheets characterize these floras. ACD: Continuing.

Sedimentology

J. C. CLARK, Indiana Univ. of Pa., and **J. C. GREENAWALT,** Delta Drilling Co. Subsurface Upper Devonian Paleogeography, NE Indiana Co., Pa. ACD: Dec. 1983.

J. A. CONRAD and **A. M. THOMPSON,** Univ. of Del. Determination of Depositional Processes and Environments for Clastic Rocks of the Ordovician Reedsville Formation in Central and South-Central Pa. Environments of deposition will be interpreted from outcrop observations and petrographic study. Primary emphasis will be on internal sedimentary structures. Initial outcrop measurements, description, and sampling are underway. ACD: May 1984.

A. L. GUBER and **TED SHUSTER,** Pa. State Univ. Studies in the Sedimentology and Paleontology of the Middle and Upper Silurian Rocks of Pa. [central and western Pa.]. Geochemical, paleontological, and sedimentological approaches are being used to define facies sequences and develop facies models for the Rose Hill, Mifflintown, and Wills Creek Formations. ACD: Continuing.

J. W. HARRINGTON, Mansfield Univ. of Pa., and **S. T. PEES,** Samuel T. Pees & Associates. Sedimentary Analysis of Shale Layers in the Whirlpool Formation of the Medina Group, Western N.Y. and NW Pa. Thin shale layers and other sedimentary features in the Whirlpool Sandstone are analyzed from Niagara Gorge, N.Y., to Crawford Co., Pa. Petrology of cores is described. Sedimentary environments are discussed. ACD: Dec. 1983.

G. G. LASH, State Univ. of N.Y. Sedimentology and Stratigraphy of the Greenwich Slice of the Hamburg Klippe, Eastern Pa. Preliminary studies of the Greenwich slice suggest that it is part of an accretionary complex. Evidence for this includes (1) style of deformation, (2) coarsening-upward sequences, and (3) longitudinal flow of channelized sediment. ACD: Late 1984.

C. D. LAUGHREY, Pa. Geol. Survey. and **JACK DONAHUE,** Univ. of Pitt. Diagenetic Trends within the Tuscarora-Medina Sequence in the Central Appalachians. This subsurface study of sandstone diagenesis is limited to the Medina Group of NW Pa. and its equivalents in the uppermost Tuscarora (Castanea) Formation of the northern Plateau. Emphasis is on the relationships between (1) sedimentary facies and diagenetic sequence, and (2) secondary porosity development and hydrocarbon generation. ACD: Aug. 1983.

R. R. LEON, Univ. of Del. The Petrology and Provenance of Sandstone and Conglomerate in the Upper Ordovician Juniata and Bald Eagle Formations, Central Pa. Petrologic data from sandstones and conglomerates in the Juniata and Bald Eagle Formations will be used to characterize the geology of the tectonic source area. This characterization may then be used to criticize existing tectonic models (or suggest new models) for the Taconic orogeny in Pa. ACD: Spring 1984.

S. T. PAXTON, Pa. State Univ. (currently with Exxon Production Research Co.), and **E. G. WILLIAMS,** Pa. State Univ. Relationships between Pennsylvanian-Age Lithic Sandstone and Mudrock Diagenesis and Coal Rank in the Central Appalachians [Northern Anthracite and North-Central fields]. Sandstone porosity varies with both coal rank and distance northwest from the Northern Anthracite field. The porosity decrease with increasing coal rank is due to differences in burial depths across the region rather than differences in geothermal gradients. ACD: Completed.

S. T. PAXTON, Pa. State Univ. (currently with Exxon Production Research Co.), and **E. G. WILLIAMS,** Pa. State Univ. The Occurrence and Distribution of Ammonium-Bearing Illites in Pennsylvanian-Age Strata of the Central Appalachians [Northern Anthracite and North-Central fields]. Ammonium illite occurs in organic-rich rocks associated with semianthracite and anthracite coals. The nitrogen source may be the coals. Occurrence at a specific rank may reflect an organic/inorganic association diagnostic of the thermal regime. ACD: Complete.

D. L. WOODROW, Hobart and William Smith Colls., and **DAVID DINELEY,** Univ. of Bristol, Bristol, England. Shoreline Facies of the Catskill Delta [N.Y. through Pa. to Va.]. ACD: 1985.

Stratigraphy

RICK DIECCHIO, George Mason Univ., **SHANNON JONES,** Exxon Co., and **JOHN DENNISON,** Univ. of N. C. Regional Compilation of Oriskany Stratigraphic and Production Trends [Appalachian Basin]. ACD: 1983.

A. D. GLOVER, C. H. DODGE, J. R. SHAULIS, and **V. W. SKEMA,** Pa. Geol. Survey. TASIC (Temporarily Available Stratigraphic Information Collection). This is a continuing program for recording stratigraphic data on active coal and clay strip mines while exposures are available. The project will provide data for future mapping and regional resource evaluation. ACD: Ongoing.

G. G. LASH, State Univ. of N.Y., at Fredonia, and **PAUL BEMBIA,** State Univ. of N.Y. at Binghamton. Petrography and Provenance of the Sacony Member, Hamburg Klippe [eastern Pa.]. This work includes detailed petrographic studies of the Sacony Member (eastern Pa.) and Araby Formation (Frederick Valley, Md.) in order to better define Early Paleozoic paleogeography and tectonics of the central Appalachians. ACD: Spring 1984.

R. C. SMITH, II and **J. H. WAY,** Pa. Geol. Survey. Tioga Ash Beds at Selinsgrove Junction, Northumberland Co., Pa. Field data including number, thickness, and relative position of the ash beds as well as the detailed mineralogic composition and character of these beds within the Tioga zone at the Onondaga-Marcellus contact are being studied. These data should serve as the basis of comparison for other ash beds at the same stratigraphic horizon throughout the state. ACD: Sept. 1983.

J. F. TAYLOR, JAMES LOCH, and **JOHN FULTON,** Indiana Univ. of Pa. Trilobites and Petrology of the Ore Hill Member of the Gatesburg Fm., [northern] Bedford Co., Pa. No pronounced lithologic change was detected near the *Elvinia/Taenicephalus* zone boundary. A collection of *"Parabolinella" occidentalis* Wilson (misassigned—probably a species of *Parabolinoides)* represents the *Parabolinoides* subzone reported from other areas of North America. ACD: June 1983.

Structural Geology

T. L. BRINK, Indiana Univ. of Pa. Geology of Portions of the Wells Tannery and Everett East 7½ Minute Quads., Bedford and Fulton Counties, Pa. A geologic map of the study area showing the locations of folds, faults, and stratigraphic contacts has been completed. ACD: May 1983.

K. J. BURNS, State Univ. of N.Y. at Binghamton. A Regional Joint Study in the Appalachian Foreland of NE Pa. and SE N.Y. A detailed investigation of regional jointing is being conducted, with emphasis on deciphering patterns and relating them to regional structural trends. Computer methods of data analysis are being employed. ACD: Sept. 1983.

E. A. ERSLEV, Lafayette Coll., **PHOEBE GRIFFITH,** Univ. of Mass., **DAVID SPEARS,** Va. Polytechnic Inst. and State Univ. and **CAROL MANN,** Lafayette Coll. Element Distribution of Solution and Slaty Cleavage in Eastern Pa. ACD: June 1984.

R. T. FAILL, Pa. Geol. Survey. Tectonic Map of Pa. Delineation of anticlines, synclines, and faults; portrayal of all igneous rocks; basement contours; structure contours on top of Onondaga in Plateau; delineation of lithotectonic units; tectonic provinces and age of deformation; unconformities; major fracture orientations; metamorphic isograds; radiometric dates; earthquake epicenters; cross sections. ACD: Dec. 1983.

J. L. JONES, York Coll. of Pa. The Reynolds Mill Fault of York Co., Pa.: Its Extent and Significance. This report is threefold: (1) the structure and distribution of the fault system, (2) the relationship between faulting and the Strickhouser iron deposit, and (3) the relationship between this fault and neighboring faults. ACD: Spring 1984.

J. R. LEVINE and **ALAN DAVID,** Pa. State Univ. Strain Analysis of Deformed Coal-Bearing Sediments in Eastern Pa. Using Coal Reflectance Anisotropy. We are studying the anisotropic optical properties of coals in eastern Pa. to help interpret their finite deformation and burial histories. The optical properties relate to the major Alleghanian structural and tectonic features of the region. ACD: June 1983.

C. M. ONASCH, Univ. of Md. Origin and Significance of Cleavage in Sandstones of the Martinsburg Fm. [Md. and south-central Pa.]. ACD: 1983-1984.

S. T. PEES, Samuel T. Pees & Associates, and **J. C. PALMQUIST,** Lawrence Univ. Morphotectonic Features Interpreted from Remote Sensing in Erie Co., Pa. Two major sets of lineaments (329° and 49°) are interpreted from Landsat images. Some of the approxiate NW lineaments locally coincide with dip reversals and other subsurface anomalies. ACD: July 1983.

S. T. PEES, Samuel T. Pees & Associates, and **J. C. PALMQUIST,** Lawrence Univ. Morphotectonic Features Interpreted from Remote Sensing in Warren Co., Pa. Sets of lineaments and elliptical features interpreted from Landsat imagery are portrayed on a 1:62,500 base map. These morphotectonic features are compared to structural interpretations of the Onondaga and Queenston tops. ACD: Oct. 1983.

S. T. PEES, Samuel T. Pees & Associates, **J. C. PALMQUIST,**

Lawrence Univ., and **R. J. LAWRENCE,** Samuel T. Pees & Associates. Fracture Trace Study of the Townville 7½′ Quad., Crawford Co., Pa. End point vector analysis of all fracture traces detected on enlarged aerial photographs covering the entirety of the Townville 7½′ quadrangle. Fracture traces are drawn on a 1″ = 1000′ base map, then reduced for publishing. ACD: Nov. 1983.

VIRGINIA PFAFF, Univ. of Cincinnati. Mechanisms of Folding in Central Pa. So far, I have worked along the Juniata River between Amity Hall and Newport. ACD: June 1985.

H. A. POHN and **T. L. PURDY,** U.S. Geol. Survey. Structural Geology of the Valley and Ridge Province [Pa., W. Va., Md., Va.].

ROB VAN DER VOO and **S. Y. SCHWARTZ,** Univ. of Mich. A Paleomagnetic Study of Oroclinal Bending in the Central and Southern Appalachians [Pa. and adjacent states]. ACD: July 1983.

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T. O. WRIGHT, Nat. Sci. Foundation. Deformation and Cleavage in the Reedsville Fm. [east-central Pa.]. The project will extend the use of graptolites to determine strain from the Martinsburg to the Reedsville Formation. The work consists of field structural mapping and collection of graptolites followed by laboratory identification and measurement. ACD: 1984.

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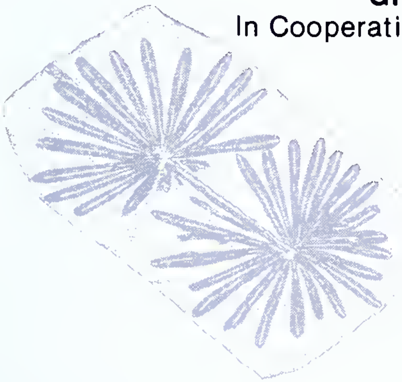

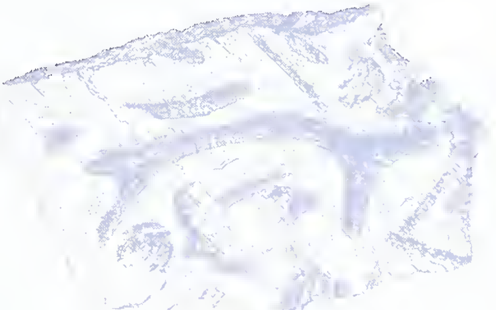

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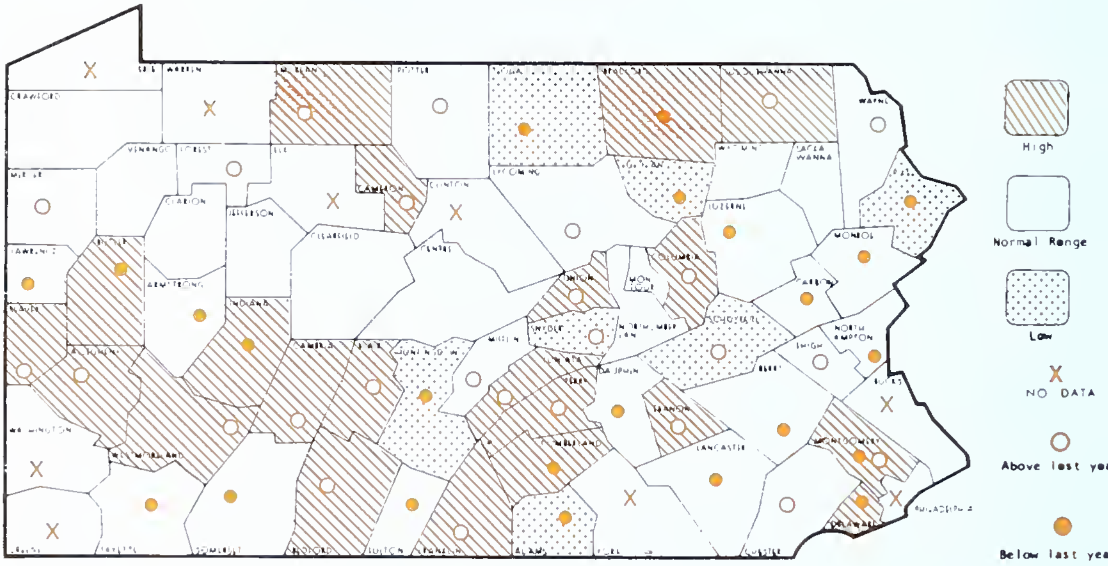

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TOPOGRAPHIC AND GEOLOGICAL SURVEY
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ON THE COVER: Resica Falls, at the intersection of Pa. Route 402 and Bushkill in Monroe County. The stream cascades 40 feet over a succession of green and red sandstones and shales of the Devonian age Catskill Formation. Photo courtesy of William Bolles, Pa. Dept. of Education.

PENNSYLVANIA GEOLOGY is published bimonthy by the Topographic and Geologic Survey, Pennsylvania Dept. of Environment Resources, Harrisburg, Pennsylvania, 17120.

Editor, Arthur A. Socolow; Associate Editor, Donald M. Hoskins.

Articles may be reprinted from this magazine if credit is given to the Topographic and Geologic Survey.

October 1983

FROM THE DESK OF THE STATE GEOLOGIST

AND THEN THERE WERE NONE

It is sad to note that for the first time in over 250 years there is not a single operating metallic mineral mine in Pennsylvania. Last month the New Jersey Zinc Company mine at Friedensville (just south of Bethlehem) closed down, ending a zinc mining history there that goes back to the 1840's.

A few years earlier, in 1977, the very impressive Grace Mine at Morgantown, Pennsylvania (within sight of the Turnpike) shut down its iron ore production, despite large remaining reserves of quality ore and a very modern mining and milling operation.

And in 1973 the world-reknowned Cornwall iron mine ceased operation, having established a record of continuous mining going back to 1742 and having served the nation's iron needs with distinction through war and peace for over two centuries.

The closing of the Friedensville zinc mine is an interesting lesson in economic geology, with emphasis on the economic aspect. As recently as 1981 this was the second largest zinc producing mine in the country, and its yield placed Pennsylvania as the sixth largest zinc producing state in the nation. Two major economic factors created the rapid demise of this historic mine with a loss of several hundred jobs: First and foremost was the enormous recent increase in the cost of electricity needed to run the battery of huge pumps which kept the mine dewatered. Secondly, was the adverse impact of the recent recession on the demand and price for zinc in this country. As in the case of the Grace iron mine mentioned above, the Friedensville closing is particularly unfortunate in light of the large remaining reserve of quality ore.

So it has come to pass that Pennsylvania, which in the 1800's and early 1900's had literally hundreds of metal producing mines, yielding a variety which included iron, manganese, chromium, lead, silver, nickel, copper, cobalt, graphite, magnesium, zinc, uranium, and vanadium ores, today has no metallic mining.

Such is the lesson of economic geology. The trend is not necessarily irreversible. New technology, new demands for resources, international crises affecting access to foreign resources, and possible discoveries of new high grade ore bodies within the state could bring metallic mining back again. This is a subject area to which economic geologists at the Pennsylvania Geological Survey will have to be attentive.

Arthur A. Socolow

Waterfalls in Pennsylvania

Alan R. Geyer and Donna M. Snyder
Pennsylvania Geological Survey

Pennsylvania's landscape is the result of a continuing conflict in nature. There is a constant struggle between the geologic forces that build the land and those that wear it down. Almost all scenic geologic features in Pennsylvania have been created from this never-ending battle.

The waterfall is an excellent illustration of this struggle of natural geologic processes. The waterfall sculptures (carves) the rocks into some of this Commonwealth's most breathtaking scenery.

Waterfalls often are grouped into three classes or types based on their origin: 1) waterfalls whose origin is due to the different resistance of the rocks to the action of running water; 2) waterfalls whose origin is due to geologic factors other than the resistance of the rocks, an example of this type would be the waterfalls created by a valley glacier that has scooped out a river valley leaving small tributary streams "hanging" and a waterfall is born; and 3) waterfalls created by the formation of calcium carbonate (dripstone) around the edge of a pool in a limestone cave. Pennsylvania's waterfalls "fall" into all three types and range in free fall from a few inches to a sheer drop of over 100 feet and in volume of water from a trickle to that of Bushkill Falls, often referred to as the "Niagara Falls" of Pennsylvania.

The following list of Pennsylvania's waterfalls has been compiled by the authors from many information sources. We know it is *not* complete and we welcome your comments, photographs, and additions.

NAME	NEAREST TOWN	COUNTY	PHYSIOGRAPHIC PROVINCE
Beaver Falls	Beaver Falls	Beaver	Appalachian Plateaus Pittsburgh Plateaus Section
Homewood Falls	Homewood	Beaver	Appalachian Plateaus Pittsburgh Plateaus Section
Scudders Falls	Pennington	Bucks	Piedmont Triassic Lowland Section
Cameleon Falls	Jim Thorpe	Carbon	Valley and Ridge Appalachian Mountain Section
Onoko Falls	Jim Thorpe	Carbon	Valley and Ridge Appalachian Mountain Section

NAME	NEAREST TOWN	COUNTY	PHYSIOGRAPHIC PROVINCE
Falls of French Creek	Saint Peters	Chester	Piedmont Triassic Lowland Section
Howard Falls	Edinboro	Erie	Appalachian Plateaus Glaciated Section
Creek Falls	Dawson	Fayette	Appalachian Plateaus Allegheny Mountain Section
Cucumber Falls	Ohiopyle	Fayette	Appalachian Plateaus Allegheny Mountain Section
Ohiopyle Falls	Ohiopyle	Fayette	Appalachian Plateaus Allegheny Mountain Section
Nay Aug Park Falls	Scranton	Lackawanna	Valley and Ridge Appalachian Mountain Section
Conewago Falls	Falmouth	Lancaster	Piedmont Triassic Lowland Section
Grant City Falls (Muddy Creek Falls)	Rose Point	Lawrence	Appalachian Plateaus Glaciated Section
Neshannock Falls	Mayville	Lawrence	Appalachain Plateaus Glaciated Section
Quakertown Falls	Hillsville	Lawrence	Appalachian Plateaus Glaciated Section
Spillway Falls	Portersville	Lawrence	Appalachian Plateaus Glaciated Section
F.L. Rickets Falls	Red Rock	Luzerne	Appalachian Plateaus Allegheny High Plateaus Section
Ganoga Falls	Red Rock	Luzerne	Appalachian Plateaus Allegheny High Plateaus Section
Harrison Wright Falls	Red Rock	Luzerne	Appalachian Plateaus Allegheny High Plateaus Section
Kitchen Creek (Adams Falls)	Red Rock	Luzerne	Appalachian Plateaus Allegheny High Plateaus Section
Oneida Falls	Red Rock	Luzerne	Appalachian Plateaus Allegheny High Plateaus Section
Whirlpool Canyon Falls	Wilkes Barre	Luzerne	Valley and Ridge Appalachian Mountain Section
Springfield Falls	Springfield Fall	Mercer	Appalachian Plateaus Glaciated Section
Buck Hill Falls	Buck Hill Falls	Monroe	Appalachian Plateaus Glaciated Low Plateaus Section
Buttermilk Falls	North Water Gap	Monroe	Valley and Ridge Appalachian Mountain Section
Clarke Falls	Analomink	Monroe	Appalachian Plateaus Pocono Plateau Section
Lee Falls	Analomink	Monroe	Appalachian Plateaus Pocono Plateau Section
Marshall Falls	North Water Gap	Monroe	Valley and Ridge Appalachian Mountain Section
Paradise Falls	Mount Pocono	Monroe	Valley and Ridge Appalachian Mountain Section
Resica Falls	Bushkill	Monroe	Valley and Ridge Appalachian Mountain Section
Spruce Cabin Falls	Canadensis	Monroe	Appalachian Plateaus Glaciated Low Plateaus Section
Stoddartsville Falls	Stoddartsville	Monroe	Appalachian Plateaus Pocono Plateau Section
Twin Falls	Marshall Creek	Monroe	Valley and Ridge Appalachian Mountain Section
Bridal Veil Falls	Shoemakers	Pike	Valley and Ridge Appalachian Mountain Section

NAME	NEAREST TOWN	COUNTY	PHYSIOGRAPHIC PROVINCE
Bridal Veil Falls	Bushkill	Pike	Valley and Ridge Appalachian Mountain Section
Brides Maid's Falls	Bushkill	Pike	Valley and Ridge Appalachian Mountain Section
Brides Maid's Falls II	Bushkill	Pike	Valley and Ridge Appalachian Mountain Section
Bushkill Falls	Bushkill	Pike	Valley and Ridge Appalachian Mountain Section
Deer Leap Falls	Dingmans Ferry	Pike	Appalachian Plateaus Glaciated Low Plateaus Section
Dingmans Falls	Dingmans Ferry	Pike	Valley and Ridge Appalachian Mountain Section
Factory Falls	Dingmans Ferry	Pike	Appalachian Plateaus Glaciated Low Plateaus Section
Fulmer Falls	Dingmans Ferry	Pike	Appalachian Plateaus Glaciated Low Plateaus Section
High Falls	Canadensis	Pike	Appalachian Plateaus Glaciated Low Plateaus Section
High Falls	Bushkill	Pike	Valley and Ridge Appalachian Mountain Section
Indian Ladder Falls	Canadensis	Pike	Appalachian Plateaus Pocono Plateau Section
Leavitt Falls	Canadensis	Pike	Appalachian Plateaus Glaciated Low Plateaus Section
Pinchot Falls (Sawkill Falls)	Milford	Pike	Valley and Ridge Appalachian Mountain Section
Raymondskill Falls	Milford	Pike	Valley and Ridge Appalachian Mountain Section
Ridgeway Falls	Rowland	Pike	Appalachian Plateaus Glaciated Low Plateaus Section
Shohola Falls	Shohola Falls	Pike	Appalachian Plateaus Glaciated Low Plateaus Section
Silver Thread Falls	Dingmans Ferry	Pike	Valley and Ridge Appalachian Mountain Section
Snow Hill Falls	Skytop	Pike	Appalachian Plateaus Glaciated Low Plateaus Section
Winona Falls	Shoemakers	Pike	Valley and Ridge Appalachian Mountain Section
Elklick Falls (Laurel Falls)	Markleton	Somerset	Appalachian Plateaus Appalachian Mountin Section
Klink Falls (Laurel Falls)	Markleton	Somerset	Appalachian Plateaus Allegheny Mountain Section
Laurel Falls	Markleton	Somerset	Appalachian Plateaus Allegheny Mountain Section
Angle Falls	Hillsgrove	Sullivan	Appalachian Plateaus Allegheny High Plateaus Section
Buttermilk Falls	Shunk	Sullivan	Appalachian Plateaus Allegheny High Plateaus Section
Cold Run Road Falls	Eagles Mere	Sullivan	Appalachian Plateaus Allegheny High Plateaus Section
Dry Run Falls	Hillsgrove	Sullivan	Appalachian Plateaus Allegheny High Plateaus Section
Dutchman Falls	Laporte	Sullivan	Appalachian Plateaus Allegheny High Plateaus Section
Lewis Falls	Jamison City	Sullivan	Appalachian Plateaus Allegheny High Plateaus Section

NAME	NEAREST TOWN	COUNTY	PHYSIOGRAPHIC PROVINCE
Lincoln Falls	Lincoln Falls	Sullivan	Appalachian Plateaus Allegheny High Plateaus Section
Twin Falls	Jamison City	Sullivan	Appalachian Plateaus Allegheny High Plateaus Section
Wenonan Falls	Sonestown	Sullivan	Appalachian Plateaus Allegheny High Plateaus Section
Falls of Devil's	Susquehanna	Susquehanna	Appalachian Plateaus Glaciated Low Plateaus Section
Bucks Falls	Starrucca	Wayne	Appalachian Plateaus Glaciated Low Plateaus Section
Twin Falls	Hawley	Wayne	Appalachian Plateaus Glaciated Low Plateau Section
Wangum Falls	Hawley	Wayne	Appalachian Plateaus Glaciated Low Plateau Section
Adams Falls	Ligonier	Westmoreland	Appalachian Plateaus Allegheny Mountain Secion
Buttermilk Falls	Buttermilk Falls	Westmoreland	Appalachian Plateaus Allegheny Mountain Section
Buttermilk Falls	Falls	Wyoming	Appalachian Plateaus Glaciated Low Plateaus Section
Wildcat Run Falls	York	York	Piedmont Piedmont Uplands Section,

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Surplus Topographic Maps

The Survey has accumulated a quantity of outdated 7½′ quadrangle topographic maps. We are offering them, in limited numbers, to teachers and troop leaders.

If you are interested in receiving a limited number of these maps contact Arthur A. Socolow, State Geologist, Dept. of Environmental Resources, Bureau of Topographic and Geologic Survey, P.O. Box 2357, Harrisburg, PA 17120. Maps will be supplied as long as they last on a first-come first-serve basis. Orders for specific quadrangles cannot be accepted.

WATER WELL COMPUTER FILE - A STATUS REPORT

Donna M. Snyder
Pennsylvania Water Well Drillers Licensing Program

History

The Bureau of Topographic Geologic Survey is responsible for the administration of the Pennsylvania Water Well Drillers Licensing Act 610 of 1956. Under the provisions of this Act a water well driller is required to complete and file with the Bureau a water well completion report for each water well drilled in Pennsylvania. In 1969, with an initial grant from the Department of Housing and Urban Development, the Bureau began coding data from the drillers water well records and a computer file was started.

Current Status

These computerized water well data have been updated recently with approximately 15,000 new records. Printouts for all 67 counties, except Philadelphia County, have been received by the Bureau and are on open file and available to the public. Each county printout consists of four reports. The first printout, called "Report Type A," shows the township, well number, owner, well location by latitude and longitude and well use. The second printout is called "Report Type B" and lists the total depth of the well, casing length, screening, drilling method, water level, yield and drawdown. "Report Type C" identifies the topographic setting, the major and minor aquifers, depth to bedrock, type of bedrock and type of surficial material. The fourth, "Report Type P," contains the depth and yield of water-bearing zones. The township and well number are used as a cross reference between Reports A, B, C and P.

The information contained on the computer printouts has not been field checked and has been classified as "unverified" data. In addition, the computer printouts, for various reasons, do not represent all water wells in a specific area. The well records used are selected records based on the drillers location description and our assigned accuracy code; i.e. can be located within 1000 feet to ½ mile (codes 2 or 3 respectively). The code is determined by the quality of the drillers location map submitted on the water well completion report form.

Information may be requested on a county basis or township basis, depending on your need and the cost involved. If 10 or fewer sheets are desired, there is no charge. If the information needed requires more than 10 sheets, the cost is 25 cents per sheet, including the first 10. Also, the Department of Environment Resources' Policy requires that the Bureau charge $7.50 per hour for staff time spent searching and assembling data in addition to the 25 cents per page charge. The printouts are available from the **Pennsylvania Geological Survey — WWI, P.O. Box 2357, Harrisburg, Pennsylvania 17120; telephone 717-787-5828.**

Future

The Department of Environment Resources' Bureau of Information Systems is currently redesigning the Water Well Inventory File to enable us to run the data on a microcomputer. Once the microcomputer and file are operational, we will enter water well information directly from the water well drillers records into the data file. Our goal, in the not too distant future, is to enter the information into the computer on a daily basis as the records are received from the drillers.

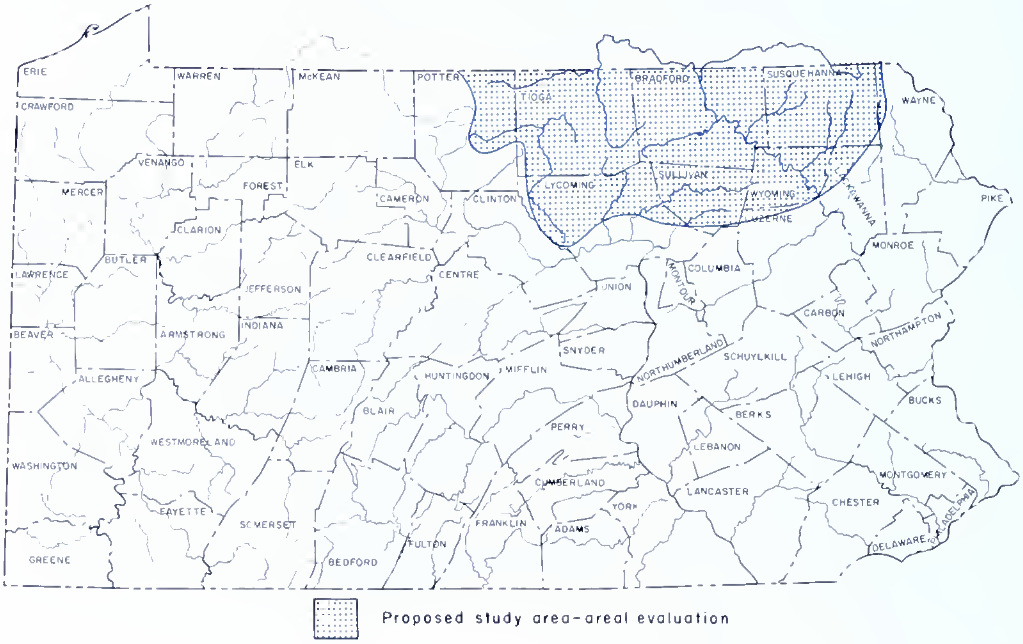
The water well computer file along with the Bureau's published groundwater reports may provide planners, engineers, geologists, well drillers, developers, and state and local governments with an excellent tool for monitoring and managing Pennsylvania's groundwater resources.

The River Valleys of North-Central PA – The Commonwealth's Best Aquifers

A team of geologists and hydrogeologists from the Pennsylvania Geological Survey and the U.S. Geological Survey has begun a study of the mineral and groundwater resources of the glacial valleys in north-central Pennsylvania. These valleys are believed to contain valuable deposits of sand and gravel and may comprise the most important aquifers of the area.

The geologists will study the composition, texture, and quantity of the sand and gravel resource. The hydrogeologists will attempt to locate and define areas where large quantities of groundwater may be developed. They will determine the natural groundwater quality of these aquifers and evaluate any man-induced contamination. By using groundwater flow models, they will attempt to show the flow system within these aquifers. All of this information will aid in the development of water supplies and in evaluating the potential use of these aquifers for the augmentation of streamflow during low-flow periods.

Two final reports are planned. They will contain detailed maps of the glacial and river sand and gravel deposits, well locations, groundwater-table, and chemical quality of the groundwater. Profiles showing the depth of these valleys and the groundwater flow patterns will be included. In addition, a comprehensive text will accompany each report.



The Arthur L. Long Lime Kiln, An Active Record of Yesteryear

Samuel W. Berkheiser, Jr., Pennsylvania Geological Survey
and
Donald T. Hoff, Pennsylvania Historical and Museum Commission

LOCATION AND SETTING — The restored and working Arthur L. Long batch kiln is located between the villages of Mandata and Urban in Northumberland County. It is in what is locally known as Stone Valley, bounded by Hooflander Mountain on the north and Fisher Ridge on the south. The kiln is about 2.5 miles due east of the active Meckley Limestone Products quarry in Jordon Township at latitude 40°40′31″N and longitude 77°47′12″W in the Pillow 7.5-minute quadrangle.

Geologically, the kiln and approximately ½-mile-long contiguous quarry are located on the faulted south limb of a doubly-plunging anticline of which the Silurian-Devonian Keyser Formation is the principle bedrock and quarry stone (Hoskins, 1970).

DESCRIPTION OF KILN — Batch kilns were used in Stone Valley from the time of the first permanent settlers to about 1936, when they were gradually replaced with the more productive draw kilns. Rotary and vertical-shaft kilns are today the chief producers and the steel industry is the primary consumer of lime. Arthur L. Long ardently operates the present batch kiln as a hobby with the small amount of resultant lump lime being used on farms within his family circle. (Fig. 1).

Batch kilns are generally characterized as having a work chamber at the base from which the initial fire is started in the firebox and the finished lump lime (burnt lime or quicklime) is withdrawn. The charge chamber is situated vertically above and the overall shape of the chamber is best described in "Longie's" own words as "egg-shaped with the pointy end down and a nickle dip of ice cream on top" (Fig. 2). Most batch-type kilns are built on a hillside for ease of charging at the top and drawing lump lime out the base. "Longie's" present kiln produces about 18 tons of lump lime with a single charge of about 6 tons of creek coal and 30 tons of limestone. This kiln may have been built around 1850 and the remains of a smaller and much older kiln are located on the upper charging level. Very close to the restored kiln, "Longie" built a 36-ton batch kiln in 1935, of which only some chestnut timbers are

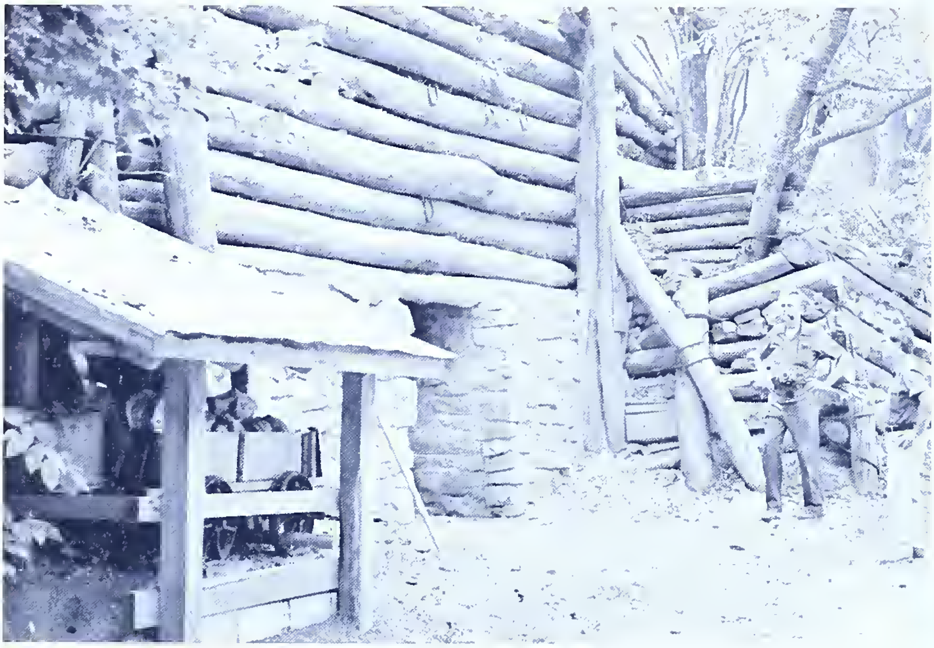


Fig. 1 Fred J. Meckley (right), who brought to our attention the Arthur L. Long batch kiln, and Donald T. Hoff discussing the hardships of burning lime. Notice the 1-ton (25-bushel) two-horse quarry wagon under the shed at left.

still visible. The ruins of 43 other batch kilns may be observed near the quarry.

QUARRY PROCEDURES — Today, we do not give much thought to producing 30 tons of variously sized crushed limestone. Many of the Commonwealth's limestone quarries average well over 100,000 tons per year. However, until about 1935, most stone was dug by hand. In 1926, when "Longie" started in the lime business at age 15, the only way to drill blast holes was by hand. A good man could drill 5 ft in a 10-hour day and was recompensed 2 cents per inch. Most holes were usually drilled at an angle to a depth of about 3 ft. Black powder was used for blasting until about 1930. At $2.25 for a 25-lb keg, black powder was considerably less expensive than dynamite. Drill holes were usually loaded and shot twice to save the labor of drilling additional holes. The first charge was meant only to crack the quarry face. Powder would be worked into these cracks for the second shot to ensure better breakage. Rubblization was completed with a 16-lb sledge held firmly between two hands. Sized limestone was loaded by hand and with a stonefork (Fig. 3) into wooden one-ton (25-bushel) two-mule wagons which would carry the stone to the kiln.

Arthur Long has developed his own geologic column for the approximately 40-ft-thick mining interval of the surrounding lime quarries. His experience and sharp eyes have subdivided most of the Byers Island Member of Keyser Formation into the following economic units from top to bottom:

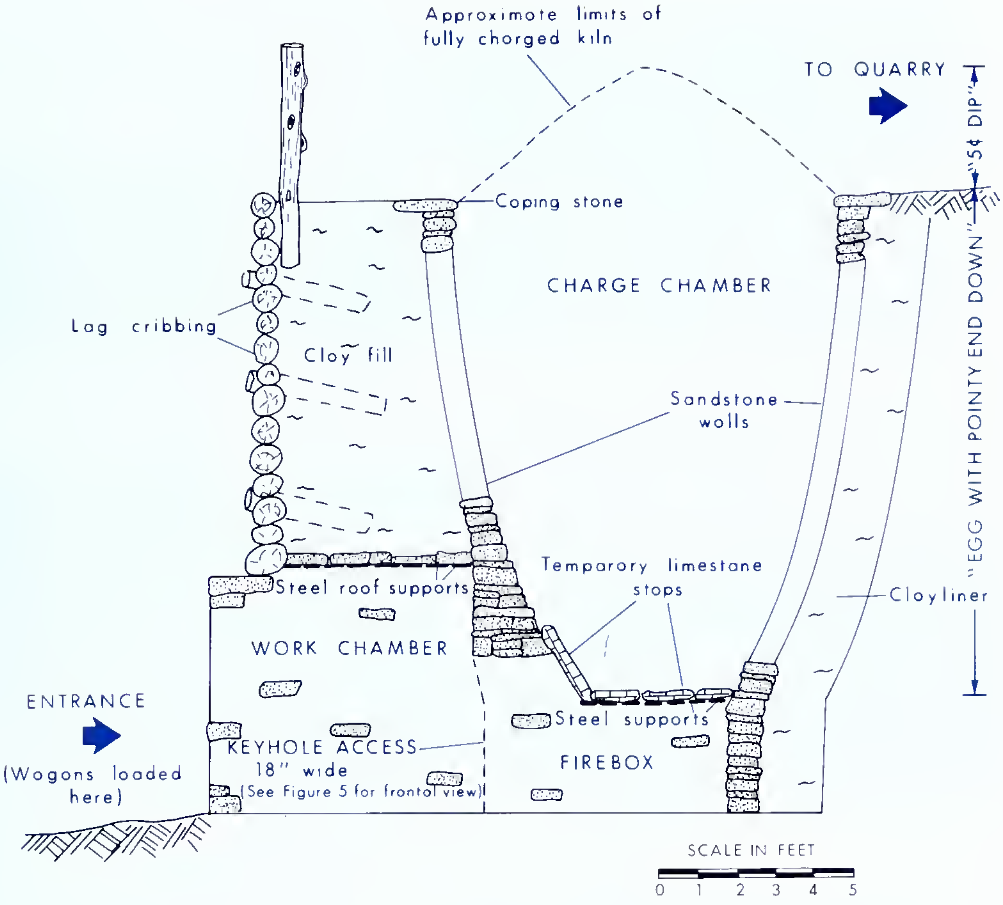


Fig. 2 Cross-section of the Arthur L. Long lime kiln. The firebox, shown here in longitudinal section, is used intially to ignite the charge above the steel supports and temporary limestone stops. The keyhole access provides draft to the firebox and charge chamber, and is used to extract the lump lime after the completed burn. Kiln is shown uncharged.

Thickness in Feet	Unit Name (from Pa. Deutsche)	Quality of Lime (as per Arthur Long)
variable	Turtle Stone (Shildrough)	"Gute Lime"
1.0	Clay Seam	"No Earthly Gute"
3.0	Pencil Stone	"No Earthly Gute"
15.0	Rough Stone	"Not as Gute Lime"
4.5	Flat Stone	"Gute Lime"
4.5	Curly Stone	"Gute Lime"
1.5	Cast Iron (Goose block)	"Gute Lime"
4.0	Solid Stone	"Best Lime"
?	Shale	"No Earthly Gute"

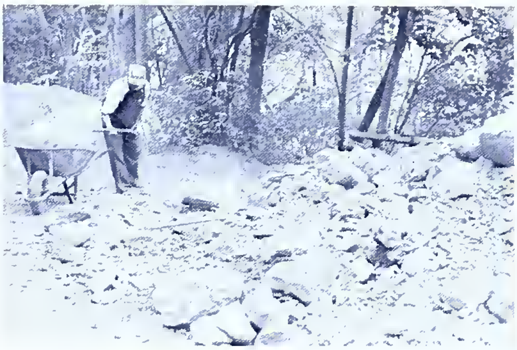


Fig. 3 Arthur L. Long using stonefork to load sized limestone. Notice 16-lb. sledge in foreground.

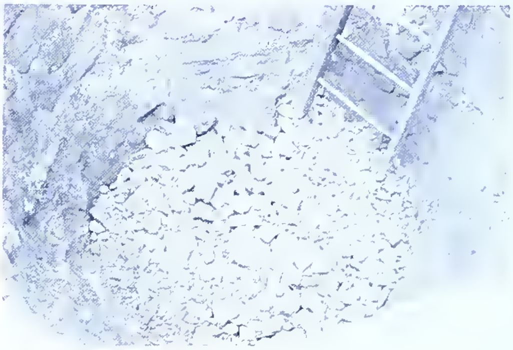


Fig. 4 View of an early charge "ring" of 4- to 6-inch limestone. Notice 1- to 4-inch-size limestone near chamber walls. 3 bushels of creek coal will follow.

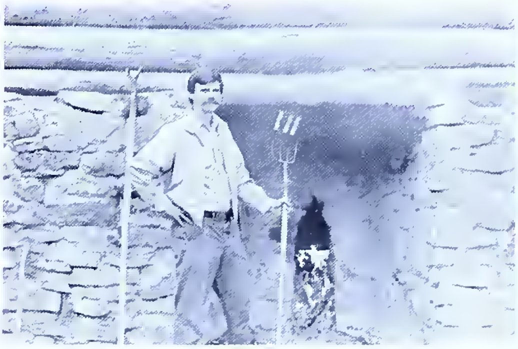


Fig. 5 Samuel W. Berkheiser, Jr. tending the initial 3-5-hr. burn in the firebox. Notice long pole to the left with forked hooks used to extract the lump lime through the keyhole, which is clearly visible at rear of work chamber.

Hoskins (1970) reports that chemical analyses from this interval further west in Meckley's quarry range from 80.8 to 84.1 $CaCO_3$. The "Turtle Stone", "Rough Stone" and "Curly Stone" of "Longie" resemble nodular bedding that Head (1969) interpreted to represent sedimentary boudinage. The "Pencil Stone" is an argillaceous slate-like unit that breaks along bedding into long flat fragments. The "Cast Iron" and "Solid Stone" are covered by slump in most of the now-abandoned quarries, but "Longie's" description suggests a very finely crystalline limestone.

CHARGING THE KILN — The kiln charge is generally constructed of successively thicker "rings" (layers) of creek coal and limestone from bottom to top (Fig. 4). The creek coal comes from dredging to the north. The limestone was originally quarried by hand from the adjacent Keyser Formation. As a general rule of thumb, about 1.25 tons of creek coal is needed to produce 4 tons of lump lime (too much coal produces slag, whereas too little coal produces lump lime with stone cores). For an average-size kiln (450 bushels), it usually takes two men about 2 days to quarry the stone and charge the kiln.

FIRING THE KILN — The kiln is ignited by starting a *wood fire in the firebox, which is kept active 3 to 5 hours. The firebox is tended through a small opening in the work chamber called a keyhole (Fig. 5). The burn length is usually between 10 days and 3 weeks, depending on atmospheric conditions and the draft established through the keyhole and kiln charge. Slaked lime (hydrated lime) from previous burns is added to the "nickel dip" as the fire breaks through the cone. When the kiln is cool enough to permit, a temporary roof is constructed over the "nickel dip" to keep rain out and prevent the quick lime from hydrating and expanding in the kiln (Fig. 6).

*Deleted adjective used by A. L. Long indicating his opinion of the low value of the wood used.

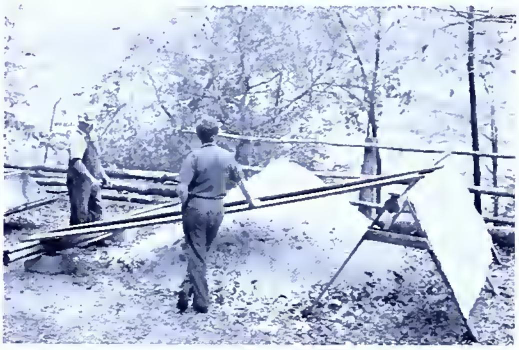


Fig. 6 Constructing temporary roof over "nickel dip" at the end of the burn. Notice the lime on the cone which was used to snuff out burn-throughs.

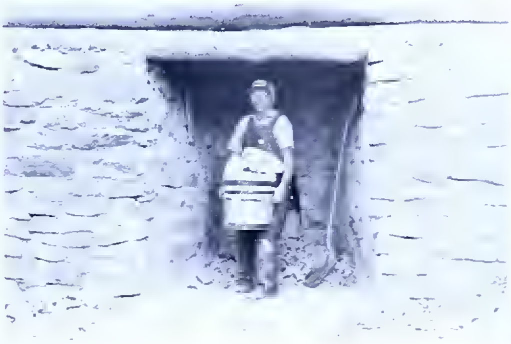


Fig. 7 Arthur L. Long hefting a "Gute Bushel" of lump lime. Notice the position of the handles on the bucket for ease of dumping. Also, the keyhole is just visible behind "Longie".

A burning kiln requires daily attention. Care must be taken to avoid suffocation from the carbon dioxide gas that is released. Chemically, the heat changes the limestone from calcium carbonate to calcium oxide (quicklime) liberating carbon dioxide gas. If water is added, the quicklime changes to calcium hydroxide (hydrated lime), which is known as slaked lime. This was the main agricultural liming material and outhouse sanitation agent until about 1945. Whitewash, which was a valuable preservative and sanitation material applied to the interior of dairy barns, is made by adding excess water.

MARKETING LUMP LIME — Until about the late 1940's, agriculture was the main end use of the burnt lime. In fact, many farmers in the valley had their own lime kilns. Even those few individuals who produced lime as a major occupation usually had another job. The demand for lime as a soil neutralizer was replaced with pulverized limestone and most batch kilns in the Commonwealth became dormant by 1950.

Horse and wagon or horse and sleigh were the main modes of transportation in the heyday of lime burning. The market area for a kiln was generally about a 30-mile radius. Wagons would be pulled up to the work chamber and loaded with wooden bushel buckets as soon as the lime was cool enough to handle (Fig. 7). The lump lime (quicklime) was extracted through the keyhole. A long pole with two hooks on the end helped to bring the lump lime through the keyhole and into the work chamber. If one had survived the ordeal of quarrying the stone and charging the kiln by hand, and hadn't succumbed to the CO_2 from the burning limestone, the operator could look forward to having the lump lime dust irritate the skin. If there was moisture present on the skin, the lime dust would hydrate and cause a burning sensation. Hydrating lump lime can "hard boil a raw egg". The quicklime and coal ash all were sold as part of the deal. Obvious slag would usually be discarded. Pulverized lump lime was not popular until the late 1940's when mechanized spreading became feasible.

The capacity of a wagon or sleigh (25, 50, or 60 bushels) determined the size of the horse or mule team (2, 4, and 5 respectively). For the far reaches of the market area, "Longie" can remember starting for the destination with the loaded sleigh at 1:00 am, spreading the lump lime during the day, staying overnight with the farmer, and returning home the next day. The lump lime was applied directly to the fields, usually at the rate of 2 tons per acre or one bushel every ten steps. The quicklime would air slake (hydrate) in the field and could be spread from the slaked piles with a shovel at a later date. Using the above formulas, one average size kiln (450 bushels) would cover about 9 acres.

CONCLUSION — Pennsylvania is now one of the nation's leading lime producers. The end use of lime has changed over the years. However, we occasionally need to look back to realize how far we have come. "Longie" plans to burn lime every fall and will welcome visitors, especially strong ones, to what he fondly refers to as the "Long's Ponderosa". We are indebted to Arthur L. Long for sharing this glimpse back into our mineral heritage to a time when the best pair of work boots in the Sears and Roebuck Catalog cost $2.25.

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Humor (?) In Geology

The following is excerpted from the Journal of Geologic Education, 1980, vol. 28, as authored by Diane Baclawski of the Geology Library, Michigan State University.

What do you get when you scare a tree to death?
Petrified Wood

What rock is cleaner than dirt?
Soapstone

On a hot day, what does a geologist use to cool off?
An alluvial fan

Who is the geologist's favorite actor?
Rock Hudson

How does a geologist buy his milk?
In quartz

Which popular music group is the favorite of geology students?
Rolling Stones

Where do coastal and marine geologists go to relax after a hard day's work in the field?
To an offshore bar!

Why does a geologist play baseball in his spare time?
So he can run on a diamond

SURVEY ANNOUNCEMENTS

STATE BOOKSTORE MOVES

The State Bookstore has moved its Harrisburg retail, over-the-counter outlet to the Capitol complex in Harrisburg and is now located in Room G-56 (ground floor) of the South Office Building. This location, behind the Capitol Building and the Old Museum Building, is very accessible to anyone visiting Harrisburg. The bookstore stocks all of our geological publications and is open 8:30 a.m. to 4:00 p.m. The address for mail order publications remains the same: P. O. Box 1365 Harrisburg, PA 17105

NEW OIL AND GAS PIPELINES MAPS

An updated and revised pair of maps has been issued by the Pennsylvania Geological Survey, one showing the principal crude oil and product pipelines in the state, and the other showing the principal natural gas pipelines of Pennsylvania.

Published in 2 colors on a scale of 1:500,000 (1 inch equals 8 miles) these maps will be of interest not only to the oil and gas industry, but also to land use and energy planners, industrial developers, municipal officials, and anyone concerned with the accessibility of these critical energy resources.

The two maps are published in a packet as Map 62, "Natural Gas Pipelines and Crude Oil Pipelines of Pennsylvania" and are available from the State Book Store, P. O. Box 1365, Harrisburg, PA 17125. The mail order price is $6.25 (plus 38¢ tax for Pa. residents); check should be payable to "Commonwealth of Pennsylvania".

SURPLUS GRAND ATLASES AVAILABLE

Approximately 50 surplus volumes of the Grand Atlas series of the Second Geological Survey of Pennsylvania (1874-1889) are available free of charge on a first-come, first-serve basis here at the Bureau of Topographic and Geologic Survey. Turned over to us by the Historical and Museum Commission, the Grand Atlases contain many beautiful maps and sections of the bituminous and anthracite coal regions, and oil and gas regions of southeastern Pennsylvania. None of the plates are folded, and many are suitable for framing. The volumes will not be mailed and may only be obtained in person. Inquiries must be directed to Arthur Socolow, State Geologist, P.O. Box 2357, Harrisburg, PA, 17120. The telephone number is 717-787-2169.

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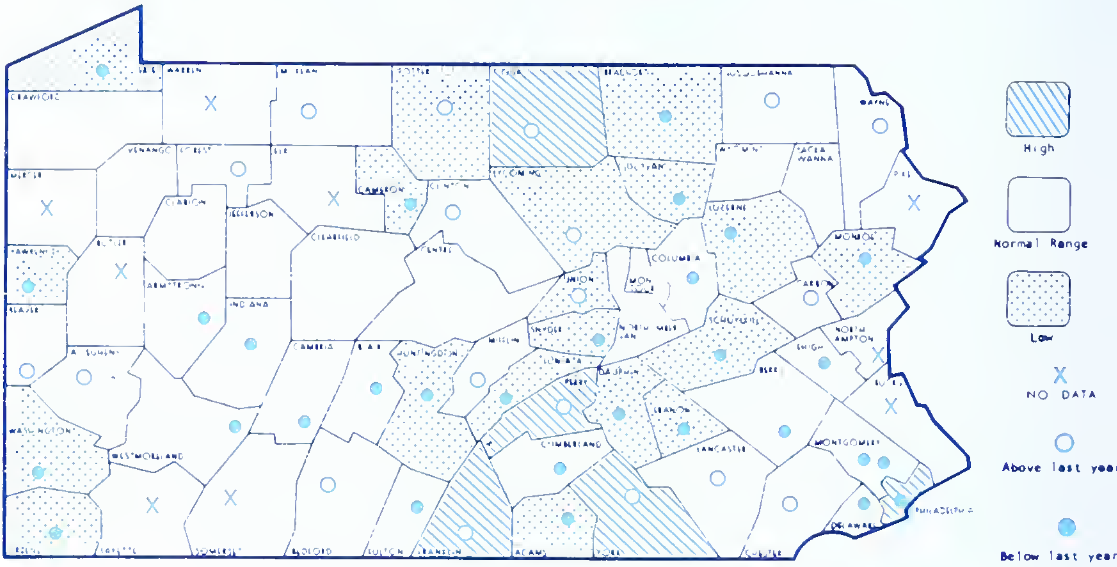

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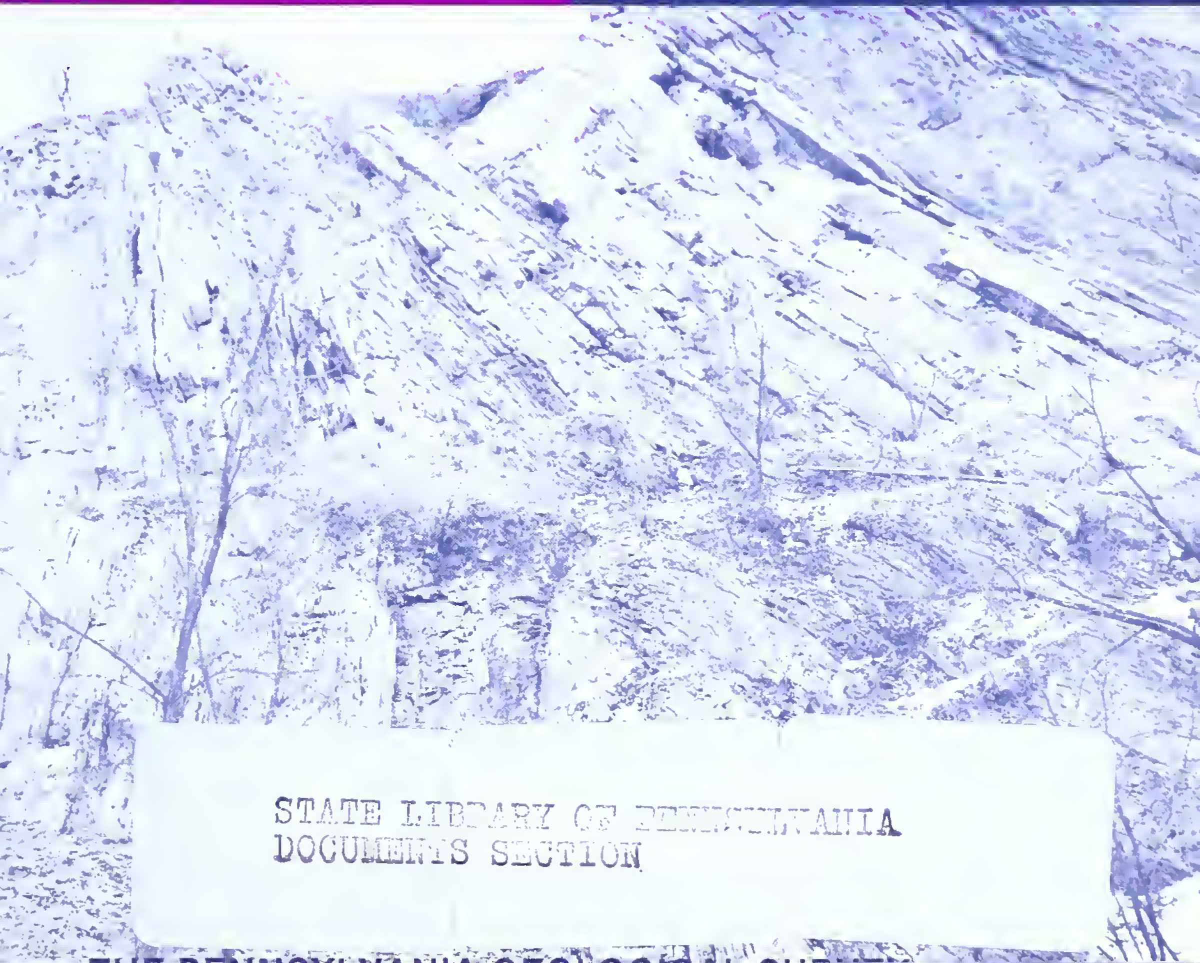

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ON THE COVER: Large anticlinal fold structure exposed in quarry on east side of Pine Creek, west of Jersey Shore, Lycoming County. View looking east. Photo courtesy of Rodger Faill.

PENNSYLVANIA GEOLOGY is published bimonthy by the Topographic and Geologic Survey, Pennsylvania Dept. of Environment Resources, Harrisburg, Pennsylvania, 17120.

Editor, Arthur A. Socolow; Associate Editor, Donald M. Hoskins.

Articles may be reprinted from this magazine if credit is given to the Topographic and Geologic Survey.

December 1983

FROM THE DESK
OF THE
STATE GEOLOGIST

Students and the Real World of Geology

From time to time we get to meet college geology students who are interested in hearing what the employment opportunities are for them when they complete their college education. Sometimes they come to our office and on other occasions we meet them on campus as we present talks or participate in career counseling. It is surprising to us, as well as disconcerting, to find how often these geology students have a limited perspective of the total scope of geology in our society, as well as the related variety of employers who utilize geologists. Neither are many of the students aware of contemporary trends or mandated procedures (such as environmental impact statements, new state and federal mining and waste disposal requirements) which involve and utilize the geologic profession.

We also find many students come to us with simplistic prejudices, such as "Mining companies are evil to the environment", and "Oil companies pay well but cheat the public", and "Coal mining should be stopped in favor of solar energy". Such excesses of opinion also demonstrate inadequate orientation on the campuses.

It would appear that some of our academic colleagues, the geology professors, are not taking enough time out of their research to help orient their students (or even themselves) into some applied aspects of the real world of geology. As essential as it is for the academic community to keep up with new scientific concepts and research procedures, so too is there a need for that community to keep abreast of the ever changing role of geology and geologists. Not to do so is a particular disservice to the geology students on whom we must depend to fulfill the diverse rolls of geologists.

We at the Survey shall continue to help in this orientation process as much as possible, but we look forward to the time when the students we meet will tell us that their profs had already enlightened them in these matters.

Arthur A. Socolow

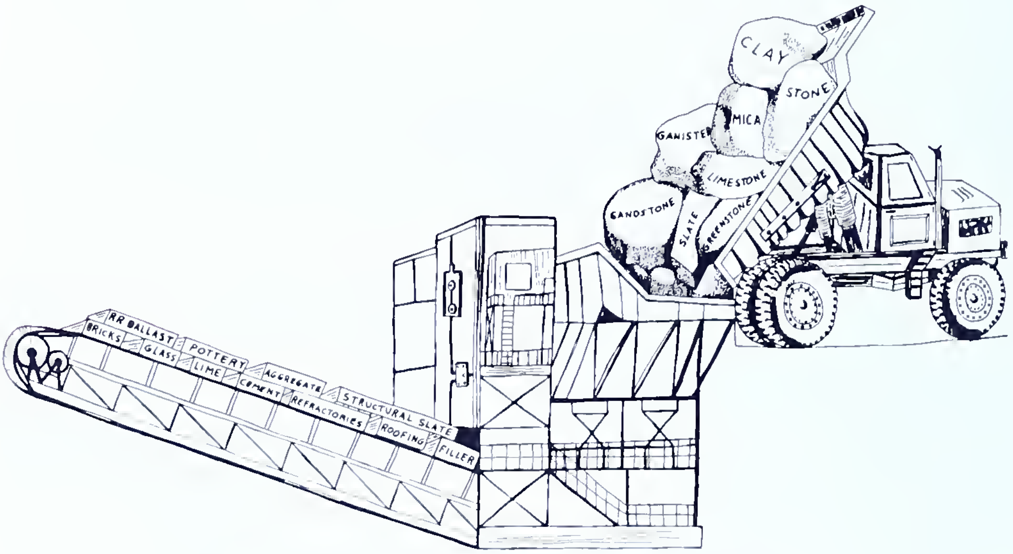
Mineral Industry Directory To Be Revised

Your Help Is Needed

The Mineral Resources Division of the Pennsylvania Geological Survey will be revising and restructuring the 1977 edition of the *Directory of the Mineral Industry of Pennsylvania*. The new edition will contain a list of operators, their products, and how they may be contacted. An accompanying map will show the producers locations, commodities produced, transportation networks, and major population centers. Of direct benefit to the mineral producer is the marketing opportunity this publication represents. This information will be valuable to consumers and industries searching for mineral products and should help Pennsylvania retain its high national ranking in mineral production.

The thoroughness and success of the revised report will be dependent on the cooperation of the Pennsylvania mineral producers. A product-oriented questionnaire will be sent out to all known producers in the near future (early 1984). Information provided by mineral producers for this project will greatly enhance its usefulness for both the producer and the consumer of non-fuel mineral commodities.

If you do not receive a questionnaire by March 31 and you believe that you should be included in this compilation of industrial mineral producers, please contact us at P.O. Box 2357, Harrisburg, PA 17120.



The Reading Hill Overthrust
A geologic controversy - Jonas vs. Miller

by Lawrence Whitcomb
Emeritus Professor
Department of Geological Sciences
Lehigh University

Controversy in geology is a recurrent event. In Pennsylvania there have been, and continue to be, many geologic controversies as new data and interpretations are presented. Controversies are enlivened when the people involved are well known and outspoken. Such is the situation with the characters in the story that follows.

Anna Jonas Stose was colorful and controversial throughout her career and, while a good observer in the field, she occasionally extrapolated evidence beyond reasonable limits; in the case of this story, she was caught up in an error involving two towns of the same name.

Benjamin L. Miller was a modest and friendly geologist who married into and joined the Quakers. A tireless searcher of details, he avoided controversy. Although newer data suggests interpretations that are close to Anna Stose's ideas, she erred in allowing a faulty site location to fuel the fires of the controversy.

The following account provides the special flavor of the episode by the author who was there in person.

—The Editors

What for many years was considered to have been the outstanding "floor fight" at an Annual GSA Meeting took place in December, 1935. Having been present, and also involved in the final solution, and, as the real story was never printed, I am reconstructing the "affair" from memory.

As is so often true, there is a great deal of background, which is important, if one knows about it. Fortunately, I do know a bit about the background, the personalities, and the unpublished solution. If I seem to ramble at first, please bear with me for one needs the backdrop before the actors appear.

Somewhere around the turn of the century a major step forward in Scottish geology was made by Peach and Horn when they described the low-angle overthrusts of the Highlands. This meant a complete revision of some past geologic interpretations and the Highlands was "The Place" to go. In 1922 I went to the Highlands with Dr. Richard M. Field, one of the Brown University faculty, afterwards at Princeton. Before heading north, Field met Horn who kindly lent him his personal field books, so that we could see some of the best exposures. They were hard to locate in that land of almost no roads and miles of walking through peat. During the next decade, date unknown, two USGS geologists, G.W. Stose and Anna I. Jonas, also visited the Highlands, to study the overthrusts.

Stose and Jonas had for years collaborated on many papers. I gather that often Jonas did the field work, brought Stose in to check the final ideas, and then published joint papers. They were a well-known team.

It is interesting to note that once Stose and Jonas got back in the United States they started to champion low-angle thrusts. First there was the question of the Martic Thrust nearer to Philadelphia and then their proposed Reading Hills Thrust. Some geologists agreed, others disagreed and a controversy was bound to develop. That in itself was good for the science. There might have been no explosion at the GSA meeting if the people involved had been different, and if some basic mistakes had not been made by both sides.

Dr. Benjamin L. Miller, Head of the Department of Geology at Lehigh University, had for years been working on the local geology, not only for the Pennsylvania Topographic and Geologic Survey, but also as a consulting geologist for the various cement companies and The New Jersey Zinc Co. He had, without doubt, done more field work in the region than anyone else, and I believe knew the area better than any other person. He also had a lot of confidential information regarding drill holes from the files of these companies. I believe that he, and probably justifiably, thought of himself as the most knowledgeable person regarding the local geology.

When word got to Miller that Stose and Jonas were going to place South Mountain, on which Lehigh University was located, as part of their newly conceived Reading Hills Thrust, he was ready for a scientific battle. He revisited old localities, rechecked some drill records, and studied places that might lend a clue to the solution. The more that he did, the more convinced he became that Stose and Jonas were wrong. He felt that he had the information that was necessary to prove his point.

The stage for what was to follow was set when the program and abstract of papers for the Rochester GSA meeting arrived in the mail. Miller felt that he must stand up for his ideas, although as a Quaker he abhorred the idea of controversy. He realized that he would have to have a rebuttal ready for the Rochester Meeting. From the time that he spent in preparation it is easy to see that he knew that some watered-down comments would not be enough.

Dr. Jonas's paper was scheduled as the last paper of a morning session. The attendance was not as large as the subject might have been expected to draw, as it was approaching lunch time. I do not think that anybody in the room expected to see a "showdown" between Jonas and Miller. The chairman of the sesson was Dr. Collins, Director of the Geological Survey of Canada. When Jonas had reached the end of her assigned time, Dr. Collins warned her that her time was up and that she would have to finish in the near future. She kept right on talking and showed no indication that she was going to comply with the chairman's request. Collins interrupted her again and, as I remember it, still again saying that she must stop! She turned to him and said " I will not let you shut me up." This jolted Collins who was not accustomed to being spoken to in that way.

Collins finally got control by stating that there would be an extra session, a continuation, after the lunch hour.

That afternoon the same lecture room that had been partly filled before lunch was filled to standing room only. Everybody expected to see a confrontation. They did. After she had had a few more words, Jonas relinquished the platform and Dr. Miller got his chance to point out what he thought about the Reading Hills Overthrust. He was adamant that it did not exist, cited a lot of local geology, which I cannot begin to recollect, but did say that there were well records made in or on the edge of the Saucon Valley which disproved Jonas's ideas. These were drillings for the New Jersey Zinc Company, and he as a consultant had seen the logs, but he could not reveal the information which was classified by the company. He also talked about the geology at a location in Limeport. Jonas came back saying that Miller's well information was no good, unless he could produce it, obviously knowing that he could not. She made references to things that she had seen which she thought were contradictory to Miller's viewpoint. At one time she came out with the fact which rolled off her tongue in spite, "any reputable Geologist would have been able to see that." It should be added that when Jonas was a student at Bryn Mawr she had taken courses under Miller, who was in Florence Bascom's department before he came to Lehigh. This spite and discourtesy had a terrible effect on Miller. He was, after all, a well-known and respected member of the profession, a local authority, and a Quaker who believed in being gentle. I watched Miller's neck get redder and redder, and we began to wonder whether he would have a stroke. His voice shook as did his hands.

Somewhere along the line Jonas mentioned some fossil trilobites that she had seen from Limeport which proved that she was right. On being questioned she said that they had been collected by Florence Bascom and that they were in the collections in the U.S. National Museum. This shook Miller who said he had not found any fossils at Limeport, and that he never knew that Florence Bascom had worked in the Limeport area, for he felt sure that if she had been up there she would have communicated with him as a former colleague. To this Jonas replied "That just shows that you do not know what happens in your own backyard." She certainly was trying to run Miller into the ground.

Then Charles Resser of the U.S.G.S., their specialist in Cambrian and Lower Paleozoic fossils, confirmed the trilobite fossils, saying that he had seen them in the Museum and that Florence Bascom had collected them. Time ran on and eventually Dr. Collins called a halt to the proceedings, but only after Resser had said that he would send some of the fossils to Miller to prove the point. He also said that he would send in a paper on the subject, to be printed by the G.S.A. along with other comments. Miller was also to present his views.

Some weeks later I was teaching a lab section when Dr. Miller came into the room. His hands were shaking as was his voice, and he was ashen grey. He never, before or afterwards, came into one of my laboratory or lecture classes. He normally would have felt that it was one of those things that one did not do. He handed me a couple of pieces of shaly limestone, one surface of which was covered by many small trilobite fossils. I cannot at this time say whether they were complete, but my recollection is that they were in most cases.

Miller said that these were the fossils from Limeport that Resser had promised to send, that he never had seen anything like them, and could and would I see what I could do about it. I might add that one of the points that Jonas had made was the fact that if Miller could not find the fossils and Bascom, a petrographer, could, it showed that he was not very good in his field. I told Dr. Miller that when I had finished the lab I would look at them and see what I could do about them.

After ten or fifteen minutes of just plain look at the specimens, I began to realize that I had seen something that was very similar. What it was, where I had seen it, and where the specimens had come from was still a blank. At least I had a clue. Then I began to remember a long narrow limestone quarry in steeply dipping beds. At the far end of the quarry there were a few inches or maybe a foot or so of shaly limestone beds, which were covered in the same way by a similar, if not identical, small trilobite. But where was the location? Then as I remembered that the quarry opened up onto a canal, the pieces began to fall together. It had been on a field trip out of

Princeton under Prof. B.F. Howell, one of two that he had been able to take us on, where we could find fossils. It was in the New Hope, Penna. area, but that was not the name that Howell gave to the location. Flash-LIMEPORT! The loading area on the canal had a few houses and went by the local name of Limeport from which the limestone was shipped down the canal to Philadelphia.

I went right to Miller and told him that I had the answer. Everything fell into place. The U.S.G.S. Folio was the New Hope folio with Bascom and Stose as the major authors; there may have been other contributors.

Miller's Quaker background immediately showed up. His first remark was that he must write Resser at once and give him a chance to withdraw his paper before it was published. I pleaded with him not to do that, but to let Resser's paper be published and then the following month come forth with his paper showing that Resser and Jonas had made a very bad mistake. His reply was that he could not do it because it would be very embarrassing to Resser. I kept pointing out that many people had been at the meeting, had heard Resser, who had a fine reputation, and would side with Jonas and Resser against Miller. I could not prevail, and Resser withdrew his paper. I never did know what he said or wrote to Miller, or even if he did.

So far as I know there were only a very few of us who ever knew the entire story. It certainly was not published any place that I saw.

Now to point out some of the mistakes that were made. Bascom's fossils were collected when she was working on the New Hope Folio with Geo. Stose. Bascom was primarily interested in the Triassic intrusives, something directly in her field. New Hope and its Limeport are in Bucks County. Bascom's fossils were identified as coming from "Limeport, Bks." This I saw on the specimens. Resser, and I presume Jonas, interpreted this as Limeport, Berks County. As a matter of fact, Limeport is in Lehigh County about eight or ten miles from Berks County. Bascom did work in Bucks County, but not in Miller's back yard in Lehigh County (not Berks). Miller should never have let Resser off the hook. He also should have asked Jonas if she had ever found any fossils!

With this fossil evidence shattered, Jonas's case was nowhere near as strong, as when supported by Resser.

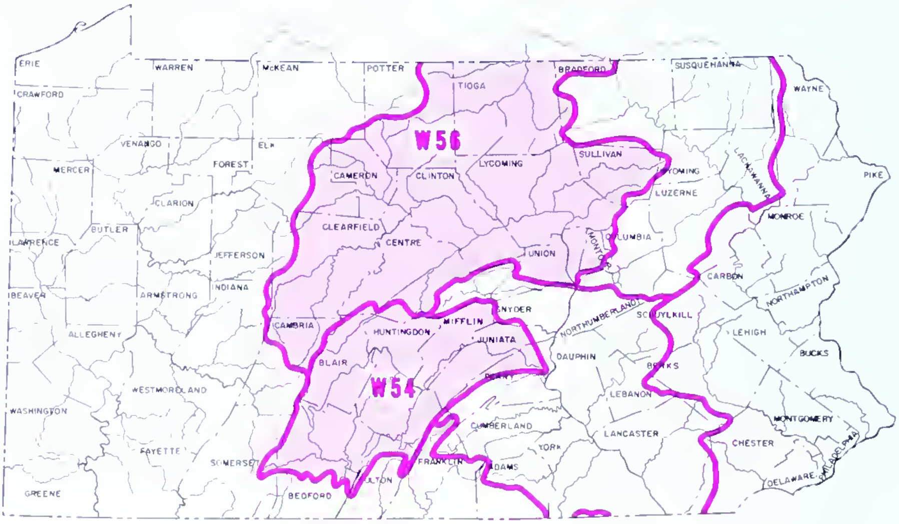
Up until that time Jonas always paid a courtesy call on Miller when she was in the area. After that date, never, although she did stop and call on Mrs. Whitcomb and me one summer afternoon when we were in the back yard. She and Stose stopped, had iced tea, a pleasant visit but no mention of the Reading Hills nor of Miller.

Enough Groundwater in the Susquehanna River Basin? We Have the Answer

For the past three years, a team of geologists from the Bureau of Topographic and Geologic Survey and the Susquehanna River Basin Commission has worked to answer this question. They have studied the water-yielding ability of the rocks from Potter County in the north to Lancaster County in the south and have found that there is an abundant groundwater supply in the Basin. Two groundwater reports, *Groundwater Resources of the Juniata River Basin* (Bulletin W-54) and *Groundwater Resources of the West Branch of the Susquehanna River* (Bulletin W-56) covering the western part of the Susquehanna River Basin have just been released by the Bureau of Topographic and Geologic Survey.

In the Juniata River Basin (including all or parts of Bedford, Blair, Centre, Fulton, Huntingdon, Juniata, Mifflin, Perry, and Somerset counties) about 11 inches of precipitation recharges the groundwater annually. By 1990, groundwater use in this basin will be greater than 30 million gallons per day with only a small fraction of the available groundwater being utilized. In detail, they describe the water-bearing properties of more than 36 different aquifers. Within each aquifer, the description of the rock is given, the yield, number and location of water-bearing zones, well depths, and an overall evaluation of the aquifer are presented. A complete record of all wells and springs inventoried is included.

The geologists found the West Branch - Susquehanna River Basin to have an equal and somewhat greater abundance of



groundwater. In this basin (involving all or parts of the counties of Bradford, Cambria, Cameron, Centre, Clearfield, Clinton, Columbia, Elk, Lycoming, Montour, Northumberland, Potter, Sullivan, Tioga, Union, and Wyoming) about 15 inches of precipitation reaches the groundwater system annually. By 1990, more than 60 million gallons of groundwater per day will be used, but this too will only represent a small fraction of the groundwater available. In report W-56 on the West Branch, the geologists describe about 35 different aquifers in the same style as the Juniata River Basin report.

Both reports, with their illustrated texts and full-color maps, offer a valuable addition to your library of the Survey's publications. For anyone interested in the water resources of these areas of the Commonwealth, now or in the future, these reports are a must.

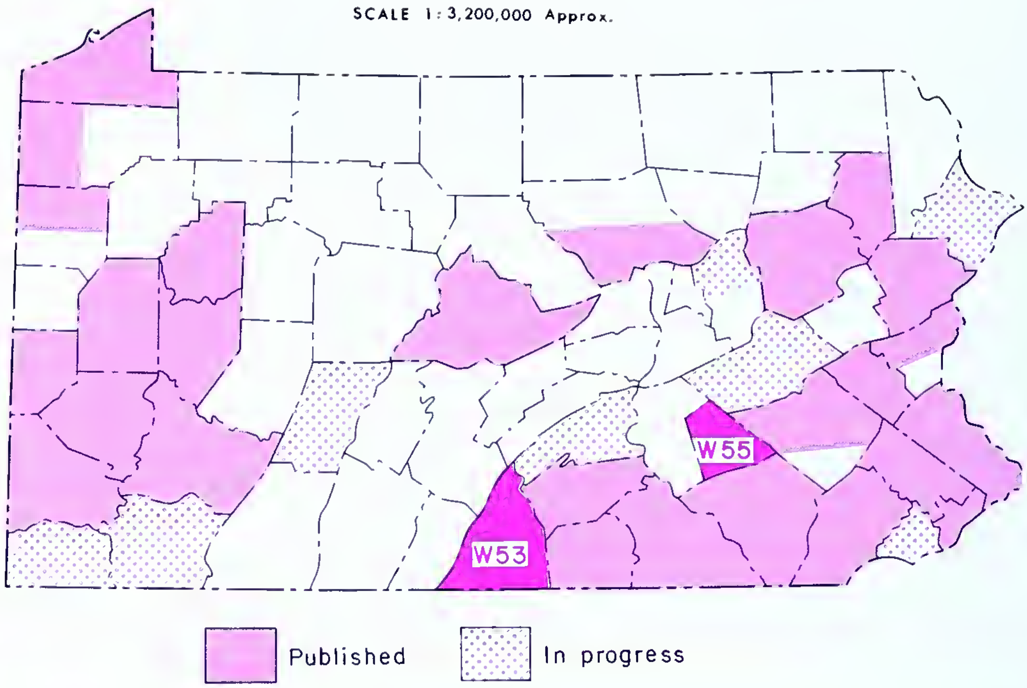
These publications are now available from the State Book Store by mail or through their new Harrisburg facility in Room G-56 of the South Office Building (Capitol complex). Bulletin W-54 is priced at $9.35 (plus 57¢ tax for Pennsylvania residents). Bulletin W-56 is priced at $15.60 (plus 94¢ tax for Pennsylvania residents). Send mail orders to the State Book Store, P.O. Box 1365, Harrisburg, PA 17105. Make check payable to Commonwealth of Pennsylvania.

New Survey Publications

County Groundwater Reports - Two More Completed

Several years ago the Survey set a goal to provide the public with a comprehensive groundwater report for each of the Commonwealth's 67 counties. Today, with the release of two additional county reports, Lebanon and Franklin, that goal is closer. The availability of these county groundwater reports will aid all those concerned with developing both private and public groundwater supplies.

Water Resource Report W-53, *Groundwater Resources of the Cumberland Valley of Franklin County* by Albert E. Becher and Larry E. Taylor, describes the aquifers with special emphasis on those that are capable of yielding large quantities of groundwater for public, industry, and private supplies. This report with a full-color geologic map shows where these high groundwater yields may be expected, depths to drill, and the water quality. Water Resource Report W-53 is available from the State Book Store, P.O. Box 1365, Harrisburg, PA 17105 for $9.30 (plus 56¢ tax for Pennsylvania



residents). Make your check payable to the Commonwealth of Pennsylvania.

Water Resource Report W-55, *Summary Groundwater Resources of Lebanon County* by Denise W. Royer, describes the many aquifers of this geologically diverse county. The extremely high groundwater yields of several limestone aquifers in the Lebanon Valley make this an important report for public and industrial use. The full-color geologic map with a detailed explanation, well records, and water quality information enable the user to select the best site for a high-yield well. Of special interest is a detailed map of water levels in the Valley. Comparison of this map with one done approximately 20 years ago shows no overall change in water levels.

Water Resource Report W-55 is sold by the State Book Store, P.O. Box 1365, Harrisburg, PA 17105 for $14.50 (plus 87¢ tax for Pennsylvania residents). Check made payable to Commonwealth of Pennsylvania must accompany order.

Geology of the Reading Area

We announce publication of the Geologic Map of the Reading and Birdsboro (7½-minute) Quadrangles, Berks County, Pennsylvania, by David B. MacLachlan. This map is number A 187cd of the Geologic Survey's Atlas series which provides detailed geologic maps and reports on quadrangles in Pennsylvania. With the previously published map of Temple and Fleetwood (7½-minute) Quadrangles (Atlas A 187ab, 1979) there is now complete coverage of all of the Reading metropolitan area except the westernmost suburbs.

The new maps covers about 110 square miles at a scale of 1:24,000 (1 inch = 2,000 feet) including much of the Oley Valley and Birdsboro on the east, and extends to Shillington and Mohnton on the west. Four units of unconsolidated surficial material and thirty-four bedrock units are portrayed in full color, with twenty-one additional subunits indicated in the older metamorphic rocks. Approximately the southern half of the map area contains moderately folded and faulted, sandstones, conglomerates, shales, siltstones, volcanics, and major intrusive diabase bodies (all of Early Mesozoic age). The central third of the northern half is largely occupied by Proterozoic gneisses and some Lower Cambrian quartzites which underlie the Reading Hills. Despite their antiquity, these rocks are entirely underlain by younger, lower Paleozoic dolomites and limestones, and minor shale units which form the surrounding bedrock units. This stratigraphic inversion (older rocks resting on top of younger formations) has resulted from a low angle thrust fault which developed during intense deformation at the time of Early and Late Paleozoic mountain building events. This fault slice is only the highest and most conspicuous of a complex of interlayered slices which forms a stack possibly as much as fifty thousand feet thick above the true basement rocks at depth.

Three interpretive cross-sections show the probable structure down to a depth of 5,000 feet below sea level.

A detailed legend on the map provides descriptions of the rock units and a brief evaluation of the ground water potential, engineering properties, and mineral resources of each unit.

This Atlas report provides an important geologic base which will be useful for planners, property owners, homesite developers, engineers, water-well drillers, and consulting geologists as decisions are made regarding proper land utilization, water supply management, waste disposal, and mineral resource development.

Atlas 187cd, titled *Geology and Mineral Resources of the Reading and Birdsboro Quadrangles, Berks County, Pennsylvania* may be purchased from the State Book Store, Dept. of General Services, P.O. Box 1365, Harrisburg, PA 17105. The cost of this Atlas mailed is $10.30 (plus 62¢ for Pennsylvania residents.) Checks should be made payable to Commonwealth of Pennsylvania.

Anatomy of a landslide in Luzerne County

by Jon D. Inners and J. Peter Wilshusen,
Pennsylvania Geological Survey

As part of an analysis of landslide susceptibility in an approximately 7350 square mile area of north-central Pennsylvania a number of known landslide occurrences, representative of those in the region, have been studied in detail. These detailed studies include measuring the landslide scar and deposit, field sampling and laboratory analysis of slide material, determination of slope steepness and orientation, identification of surficial and bedrock geologic features and determination of time of occurrence where possible.

The landslide susceptibility project is a cooperative effort of the Pennsylvania Geological Survey with the U.S. Geological Survey, and is part of a larger study that has included much of the Appalachian Mountain region in the eastern United States. Its purpose is to identify those areas where landslides may pose a risk to future development and to describe the extent and nature of that geological hazard in this area. A description of one of these landslide occurrences follows.

The Nescopeck landslide is located on a steep rocky escarpment 0.5 miles southeast of the borough of Nescopeck, Luzerne County, Pennsylvania (Lat. 41°02′50″N/Long.76°12′20″W, Berwick quadrangle; Figure 1). The escarpment forms the north slope of a

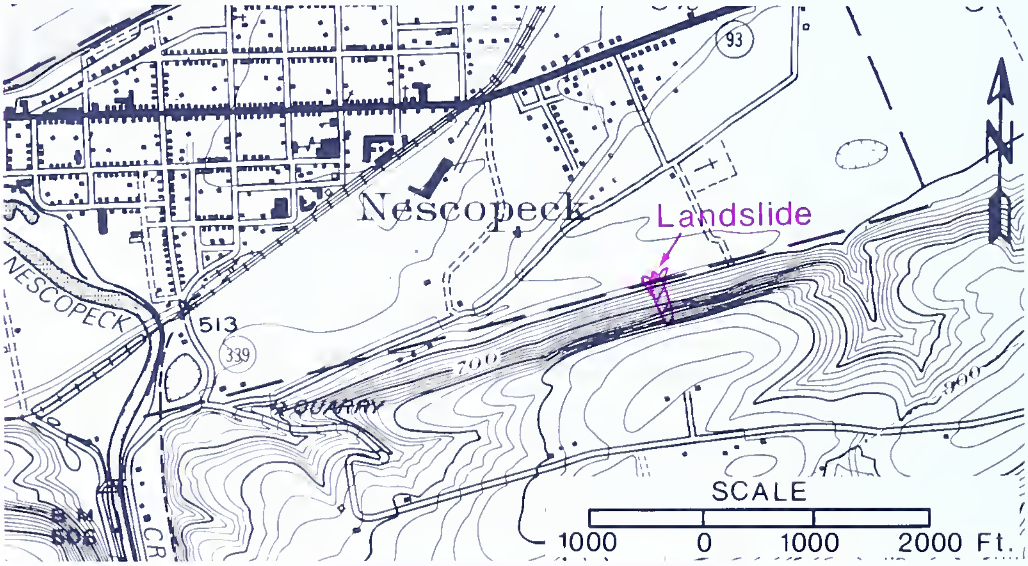


Figure 1. Location Map

prominent ridge, known locally as River Hill, underlain by erosionally resistant, south-dipping sandstone, siltstone, and silty shales of the Upper Devonian Trimmers Rock Formation (Inners, 1978). Vertical bedrock cliffs, some of which are a few tens of feet high, jut out of the upper part of the escarpment at irregular intervals, adding significantly to the ruggedness of the terrain. The abrupt drop-off of the bluff on River Hill near Nescopeck may be mainly the result of direct fluvial erosion and undercutting at a time when the Susquehanna River flowed several thousand feet south of its present position. Pre-Woodfordian (prior to 25,000 years ago) glacial scour may also have contributed to oversteepening of the hillside.

The landslide forms a narrow scar extending from near the top of River Hill to its base (Figure 2). Table 1 summarizes important physical dimensions and characteristics of the slide that were either measured in the field or computed from field data. Note the extreme steepness of the slide near the crown and the low height of the bounding scarp. The latter reflects the thin-skinned nature of the landslide, less than 3 feet of regolith and colluvium having been involved. Because the surface of rupture lies at the bedrock - colluvium interface, bedrock is exposed at several places in the denuded area of the slide (Figures 2 and 3).

An important aspect on the Nescopeck landslide - its velocity -must be inferred from its geometry and the slide's effects on stationary objects in its path. The steep slope, narrow "track", and large denuded area all suggest relatively rapid mass movement. In addition, abrasion of bark from the upslope sides of trees hit by the moving debris is almost indisputable evidence of high velocity downslope translation of soil and rock debris (Figure 4).

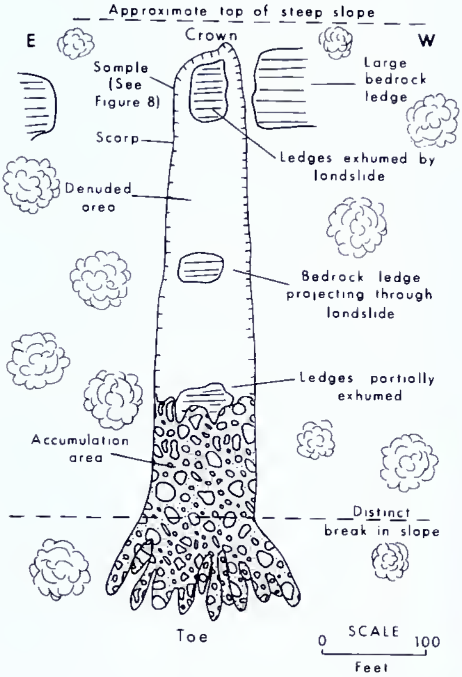


Figure 2. Schematic diagram of the Nescopeck landslide, showing bedrock ledges, sample location, and relationship of accumulation area to denuded area.

Table 1. Physical characteristics of the Nescopeck landslide.

Length	525 ft.
Width	
Near crown	63 ft.
Middle	90 ft.
Toe	175 ft.
Altitude	
Crown	880 ft.
Toe	600 ft.
Height (=vertical fall)	280 ft.
Orientation	N15W
Slope	
Near Crown	50-55°
Middle	40°
Toe	10-15°
Average height of bounding scarp	2 ft.
Thickness of displaced material near toe	6 ft.
Total volume of displaced material	1500 yds.^{3}

The material of the Nescopeck slide is a reddish-yellow, stony, extremely silty colluvium-regolith mixture. A sample collected near the crown (see Figure 3) consists of 48 percent angular gravel, 8 percent sand, 34 percent silt, and 10 percent clay and has a liquid limit of 23 (low) and a plasticity index of 5 (very low). According to the Unified Soil Classification, material with these properties is a silty-to-clayey gravel (GM-GC).

The most critical attributes of the slide material from a geotechnical standpoint are: (1) the grain-size distribution of the matrix, the sand-silt-clay binder surrounding large rock fragments; and (2) the shape and orientation of rock fragments. The dominant size fraction in the matrix is silt (66 percent). Soils with high silt contents tend to lack cohesion (low plasticity index) and to liquify on addition of only moderate amounts of water (large difference between liquid limit and plasticity index). Examination of the scarp near the crown shows that rock fragments in the regolith-colluvium are bladed and platy (a result of breakage along bedding, cleavage, and joint partings in the bedrock), and that these fragments are oriented roughly parallel to the slope. Potential instability brought about by this combination of fragment shape and orientation is rudely revealed to anyone who tries to climb the steep slope of River Hill, either in the landslide "track" or in adjacent undisturbed slope areas.

Based on the geometry of the slide scar, the volume and nature of soil materials, and the probable velocity of movement, the

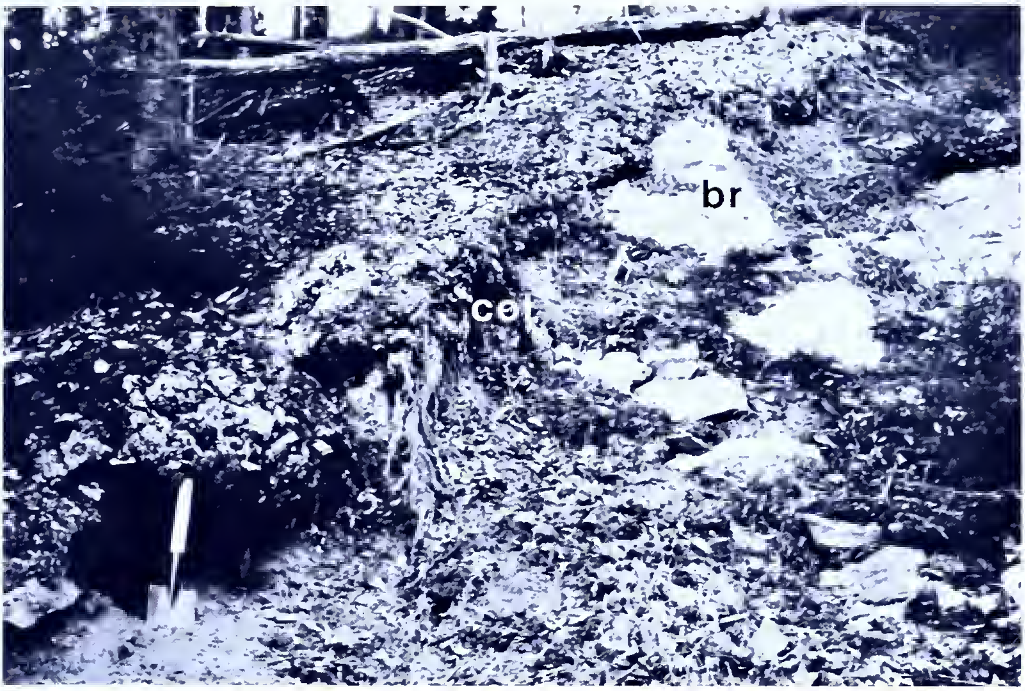


Figure 3. Scarp on east side of Nescopeck landslide, approximately 50 feet downslope from crown. Note thinness of soil mass involved in slide. (Shovel is 18 in. long). Sample for size analysis was collected in this area. (col = regolithcolluvium; br = bedrock).

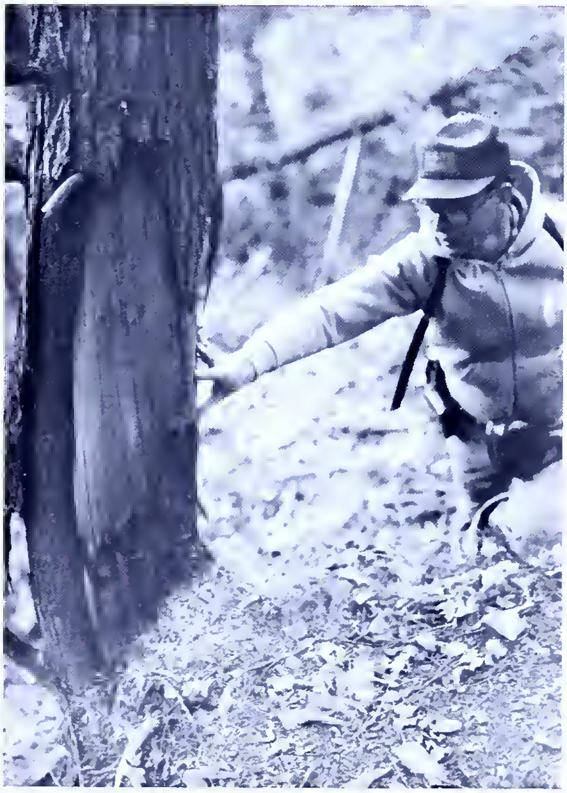


Figure 4. Abraded tree trunk in lower part of slide area. Note downslope bend in truck (caused by earlier soil creep not related to landslide) and accumulation of debris on upslope (right) side.

Nescopeck landslide is best classified as a debris avalanche. This type of mass movement involves the sudden flowage of completely water saturated soil and rock on a relatively steep slope, producing a long, narrow scar on the slope and an accumulation of material at the toe (Wilshusen, 1979). Almost invariably, debris avalanches are preceded by heavy, concentrated rainfall. Rapid flowage caused by spontaneous liquification of the material is the predominant mode of movement (Pomeroy, 1980). The Nescopeck landslide is similar in width, length, depth, and volume to many debris avalanches that occurred in the Johnstown area during the heavy rainfalls of July 19-20, 1977 (Pomeroy, 1980; Hoxit and others, 1982).

According to a local resident, the Nescopeck landslide occurred at a time of intensely concentrated rainfall associated with Tropical Storm Agnes in June, 1972. Heavy rains began in the Berwick-Bloomsburg area on Wednesday afternoon, June 21, and continued into Thursday evening, June 22. More than 11 inches fell on Thursday alone (Bloomsburg Press, 1972). The landslide probably took place on one of these two days, most likely on the 22nd. Large bedrock ledges to the east and west may have been responsible for localizing the slide at a particular spot on the steep River Hill escarpment (Figure 2). Regolith and colluvium in the area between bedrock crags became saturated with water and suddenly flowed downslope at an extremely high velocity. This energy was quickly dissipated when the slide mass surged out onto the gentle colluvial apron that covers the south edge of the flat outwash terrace bordering the Susquehanna River.

In recent years, several house trailers have been built against the base of the River Hill escarpment southeast of Nescopeck. One of these is only about 500 feet west of the Agnes-induced debris avalanche described in this paper. Continued residential development along the base of the escarpment increases the chances that a recurrence of landsliding on the steep slope above could cause injury or death, and financial loss for property owners.

Additional information is available on this occurrence including data on material analysis and photographs of the landslide. Any reader who is interested may contact the Survey for this information.

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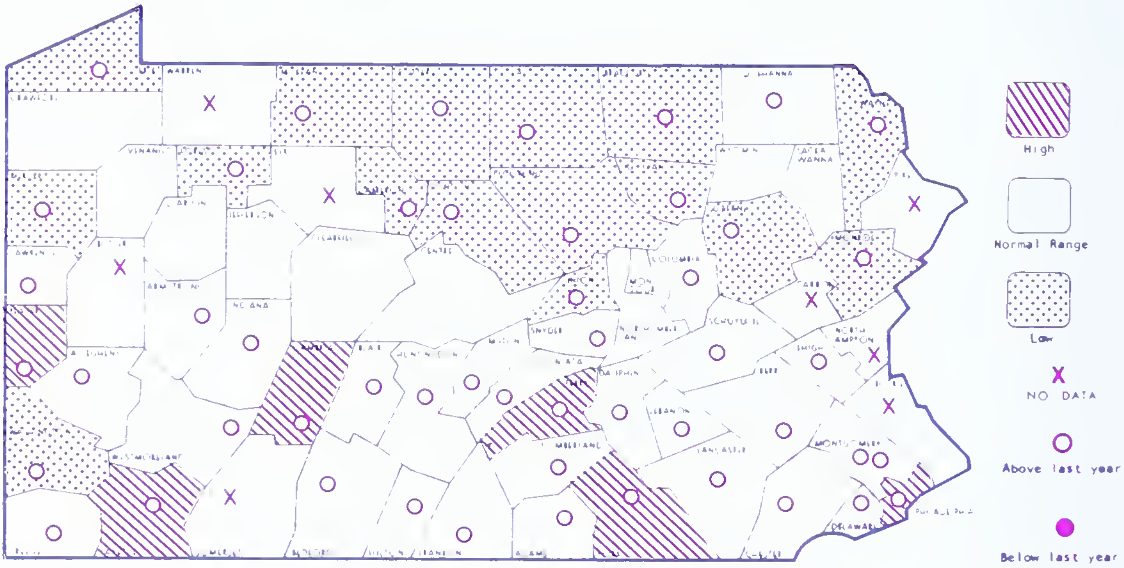

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ON THE COVER: French Azilum Overlook, 10 miles southeast of Towanda, along Rt. 6, Bradford County. View of ice-choked Susquehanna River meandering through Appalachian Plateau country; site of colony for refugees from the French Revolution, settled in 1793.

PENNSYLVANIA GEOLOGY is published bimonthy by the Topographic and Geologic Survey, Pennsylvania Dept. of Environmental Resources, Harrisburg, Pennsylvania, 17120.

Editor, Arthur A. Socolow; Associate Editor, Donald M. Hoskins.

Articles may be reprinted from this magazine if credit is given to the Topographic and Geologic Survey.

VOL. 15, NO. 1 **FEBRUARY, 1984**

FROM THE DESK OF THE STATE GEOLOGIST

YOU CAN LEAD A HORSE TO WATER—

Geologists are supposed to be patient. After all, they deal with earth processes and events involving hundreds of millions of years duration. But frustration has been creeping up on some of us geologists, and when it does, there must be a pretty good reason.

Over ten years ago, the U. S. Geological Survey and the Pennsylvania Geological Survey started to issue a series of maps of southwestern Pennsylvania detailing the location of past and potential landslides. Yet, to our knowledge, no county or local community of that area has seen fit to adjust its zoning or to require competent engineering plans when developing the hazardous sites. And we continue to receive horror stories of ruination of homes, sewage systems, and roads involving losses in the millions of dollars, much of it the life savings of private citizens.

In central and eastern Pennsylvania we have identified and described limestone terrains where formation of sinkholes is a continuing and recurrent phenomenon. We have observed the loss of homes, schools, roads, waterlines, parking areas, bridge piers, and runways. Again, we are not aware of zoning or landuse planning that will make use of our geologic forewarnings so as to protect and prevent such grievous losses.

In 1976 I wrote in this column ("Is Anybody Listening") on the same subject. At the risk of repeating myself I am again pointing up the lethargy to messages being issued by geologists and hydrologists.

Fortunately, Pennsylvania does not face the problem of avoiding the locations of earthquakes, active faults and volcanoes - such as most of the public is ignoring in our western states. But how much have we done to forestall the damages of another Agnes episode? Or the sinkholes of the Valley Forge and Great Valley communities? Or the landslides of Allegheny County?

Currently the Pennsylvania Survey is working on a project to identify the landslide problem areas of north-central Pennsylvania. When completed later in 1984 it will be published and available to all, just as the earlier ones for western Pennsylvania. The identification of those geologic hazards could be a valuable contribution — but only if someone listens. Maybe our readers can help prevent our frustrations.

Arthur A. Socolow

HIGH-ALUMINA CLAY DISCOVERED IN BERKS COUNTY

by S.W. Berkheiser, Jr. and
R.C. Smith, II, Pennsylvania Geological Survey

Up to 25 ft of light-colored kaolinitic clay has been discovered in the idle Berks Silica Sand quarry near Alsace Manor. This whitish clay is suitable for medium to high-duty refractories (PCE 30 to 31½). The Berks Silica Sand quarry is located approximately 1 mile west of Alsace Manor and just north of Pricetown Road. This is in Alsace Township, 2.5 miles southeast of Temple. The quarry is in the Temple and Fleetwood 7½′ quadrangles at latitude 40°26′46″N and longitude 75°52′30″W. The discovery of this previously unreported clay is an indirect outgrowth of a carborne scintillometer survey for uranium and thorium in the Reading Prong. During the carborne survey, a few areas of extremely low gamma-ray activity were noted over white "soils". These apparent uranium and thorium lows were field-checked for high-purity silica. Only fair-quality silica was found in the area, but discovery of the leached clay resulted.

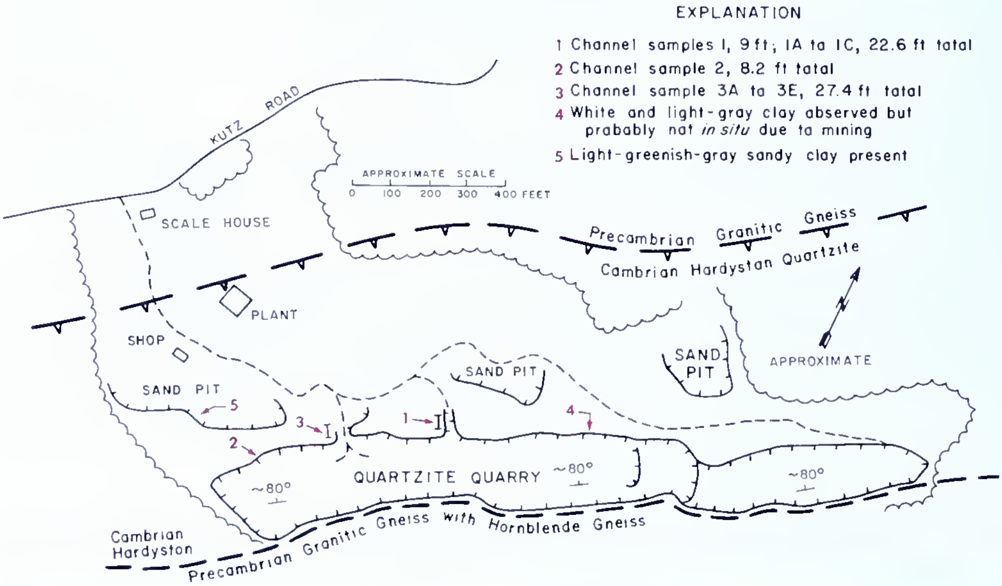
EXPLANATION
1 Channel samples I, 9 ft; IA to IC, 22.6 ft total
2 Channel sample 2, 8.2 ft total
3 Channel sample 3A to 3E, 27.4 ft total
4 White and light-gray clay observed but probably not *in situ* due to mining
5 Light-greenish-gray sandy clay present
APPROXIMATE SCALE
0 100 200 300 400 FEET
KUTZ ROAD
SCALE HOUSE
PLANT
SHOP
SAND PIT
SAND PIT
SAND PIT
APPROXIMATE
Precambrian Granitic Gneiss
Cambrian Hardyston Quartzite
QUARTZITE QUARRY
~80°
~80°
~80°
1
2
3
4
5
Cambrian Hardyston
Precambrian Granitic Gneiss with Hornblende Gneiss

Figure 1. Sketch map of the geology and clay sample locations from Berks Silica Sand quarry, Alsace Township, Berks County, Pennsylvania.

The east-west trending quarry is developed in an imbricate thrust sheet of the Lower Cambrian Hardyston Formation. MacLachlan (1979) described the formation in this area as a 600-ft-thick clastic sequence characterized by white to dark-gray quartzite and feldspathic sandstone typically containing a quartz pebble conglomerate at the base. The clay zones, with apparent measured thicknesses greater than 25 ft, occur about 160 ft stratigraphically above the steeply, north dipping, basal conglomerate and an unconformity with the underlying Precambrian gneisses. This clay may be continuous at this horizon along the total length of the developed quarry (1800 ft.) and is a nuisance to the quarrying of silica. This stratabound clay horizon may also act as an aquitard for ground water migration. It marks a boundary between massive, fractured, indurated, quartzite to the south and a more friable sandstone to the north.

Typically these light colored kaolinitic clays appear conformable with the surrounding quartzite and sandstone. Relict bedding is usually preserved (Figures 2 and 3). In some samples, sandstone and quartz are present in the clay in varying amounts as are minor clay streaks of moderate orange-pink to light-red and very-pale-

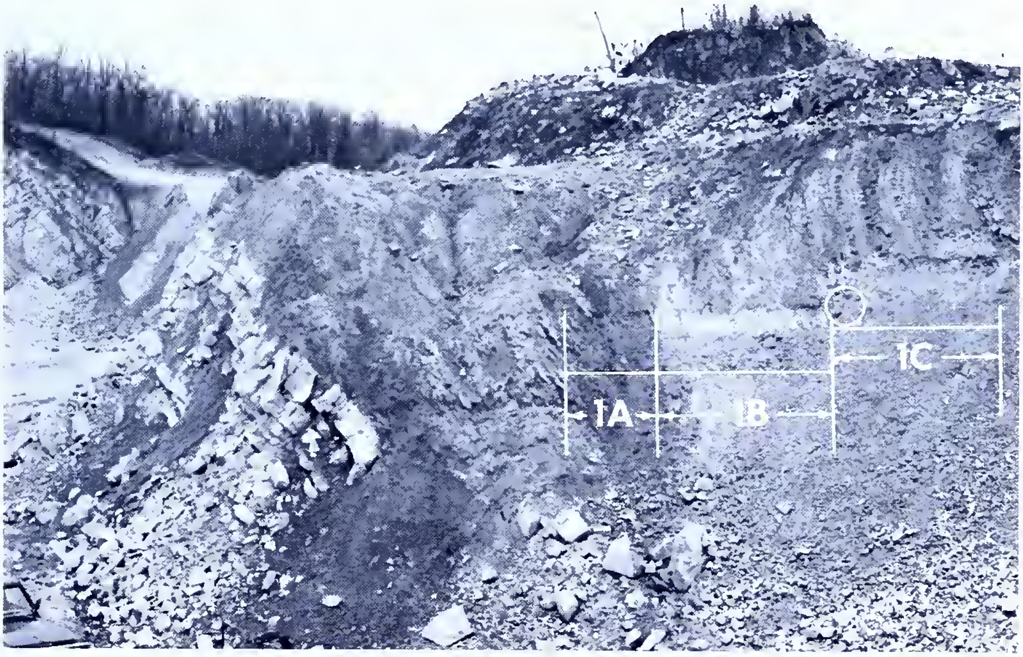

Figure 2. Northwest view of gangway cut into the north rib of the quarry at location 1 (Fig. 1) 250 ft east of the main quarry access showing clay channel samples 1A through 1C. Sample 1B is roughly equal to the discovery sample 1. Notice the relict bedding in the clay having an approximate attitude of N65E and 80 NW. Mattock (circled) is approximately 2.5 feet in length. See Table 1 for sample descriptions.

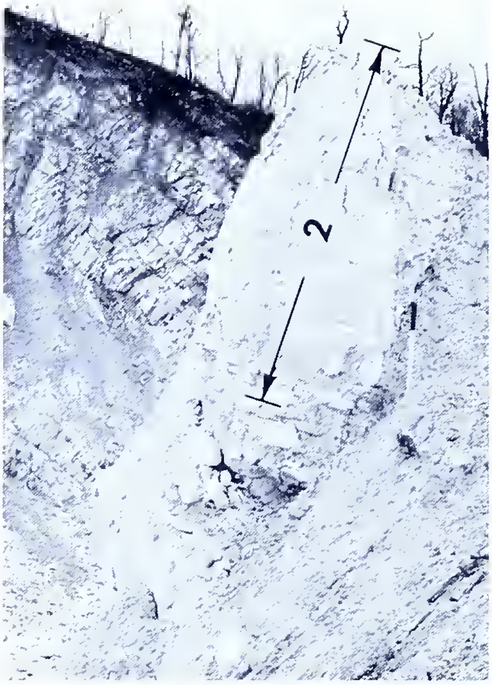

Figure 3. Northwest view of the slightly slumped portion of the north rib showing the 8 ft (2.5 m) long channel sample of Sample 2. Apparently unlike samples 1A through 1C, this light-colored clay occurs directly above a massive quartzite bed. Mattock is about 2.5 ft. in length.

orange to light-greenish-gray clays (varicolored). Observations along the strike length of the quarry suggest that the rarer white clay may occur as stratabound lenses throughout the apparently thicker sequence of varicolored, quartzose clay and weathered sandstones. The clays are very sticky and plastic when wet. Colors are also more intense in moist samples. The preserved relict bedding and interbedded sandstone intervals suggest that these clays are a weathering and leaching product of mudstones and claystones.

Atomic absorption analyses of the discovery sample (equivalent to sample 1B) yielded SiO_2 65.5%, $A1_2O_3$ 22.9%, TiO_2 1.09%, K_2O 1.13%, MgO 0.43%, CaO 0.05%, Na_2O 0.03%, and total iron as Fe_2O_3 0.95% (R. C. Smith, II and J. H. Barnes). Assuming that the K_2O is present in muscovite, that the remaining $A1_2O_3$ is in kaolinite, and that the left over SiO_2 is quartz; then this white clay contains about 10% muscovite, 50% kaolinite, and 40% quartz. This is consistant with X-ray diffraction data listed below by R. C. Smith II and L. T. Chubb:

Channel Sample Number	Relative Peak Height, Kaolinite	Relative Peak Height, Quartz	Relative Peak Height, Muscovite
1	0.59	0.36	0.05
1B	0.64	0.28	0.08
2	0.68	0.23	0.09

TABLE 1
Sample Description and Potential Uses of Clay Intervals

SAMPLE NUMBER	SAMPLE DESCRIPTION (Colors given are for dried clay using the Munsell color chart)	APPARENT THICKNESS, SAMPLED INTERVAL	PCE*	
1	Channel sample of white to yellowish-gray clay; minor streaks of varicolored clay; some quartz sand beds; 1981 discovery sample	9.0 ft	31-31.5	
1A	Channel sample of very pale orange, mottled basal clay; iron-stained basal sandy clay	4.4 ft	30	continuous sample
1B	Channel sample of white to yellowish-gray clay; minor streaks of varicolored clay; quartz sand beds rare	12.0 ft	31	
1C	Channel sample of silty, white to yellowish-gray clay with interbedded sandstone intervals; total sampled interval with sandstone, 11.2 ft.	6.2 ft	30	
2	Channel sample of laminated, silty, white to yellowish-gray clay; slumped exposure	8.2 ft	31	
3A	Channel sample of slightly silty, white to light-greenish-gray clay; some varicolored streaks	7.2 ft	30	continuous sample
3B	Channel sample of silty, white to yellowish-gray clay; some varicolored streaks	7.2 ft	30	
3C	Channel sample of sandy white to very pale orange clay	3.1 ft	30	
3D	Channel sample of white to yellowish-gray clay; minor sandy beds throughout; some varicolored streaks	7.5 ft	31	
3E	Channel sample of sandy, white to yellowish-gray clay	2.3 ft	31	

* Data provided by U.S. Bureau of Mines

Potential uses as determined by U.S. Bureau of Mines

Sample 1, suitable for high-duty refractory

Samples 1A through 3E, suitable for medium-duty refractory

Samples 1, 1B, 1C, 2, 3A, and 3B suitable for structural clay products whereas samples 1A, 3C, 3D, and 3E are not because they are too soft

Samples from three separate exposures in this quarry (Figures 1, 2 and 3) were submitted to the United States Bureau of Mines (USBM) for preliminary ceramic evaluations. Results of these analysis and descriptions of channel samples are listed in Table 1. Traditional uses of kaolinite include: pottery; as a pigment or extender in the paper, paint, rubber and plastics industries; cement additive; refractory; and many other specialized applications (Patterson and Murray, 1975). Perhaps the highest end-use value for this occurrence, if mineable tonnages could be proven, would be for a source of refractory clay. Of the 896 clay-shale samples recently tested by the survey (O'Neill and Barnes, 1981), this clay has the highest PCE value published. The nearby cement industry might also be able to use this clay in the manufacture of white Portland cement. Alternatively, these clays could be suitable for impermeable liner material in lagoons or landfills in this industrialized area. Local potters might be able to use some of this material as an indigenous Berks County clay source.

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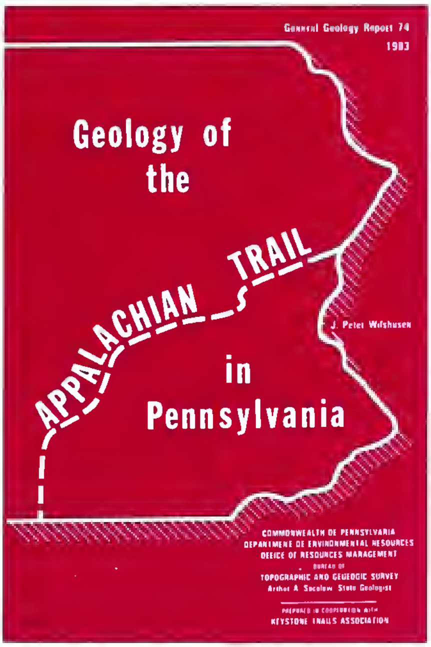
Geologic Map of the Altoona 15′ Quadrangle Placed on Open File

The Pennsylvania Geological Survey is placing on Open File the newly compiled geologic map of the Altoona 15′ quadrangle at a scale of 1:24,000. The map area comprises the Altoona, Bellwood, Blandburg, and Tipton 7-½ minute quadrangles and lies mostly in northern Blair County, with smaller portions in Cambria, Clearfield, and Centre Counties.

The geologic map will be published in 1984 as part of Atlas report 86 (by Faill, Glover, and Way) consisting of the map, cross sections, and written text. A hand-drawn version of the map may be examined at the Survey offices, Room 914, Executive House, 101 South Second Street, Harrisburg, Monday through Friday from 8:00 a.m. to 4:00 p.m.

The geology of the Appalachian Trail in Pennsylvania



General Geology Report 74
1983

Geology of the APPALACHIAN TRAIL in Pennsylvania

J. Peter Wilshusen

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Arthur A. Socolow, State Geologist

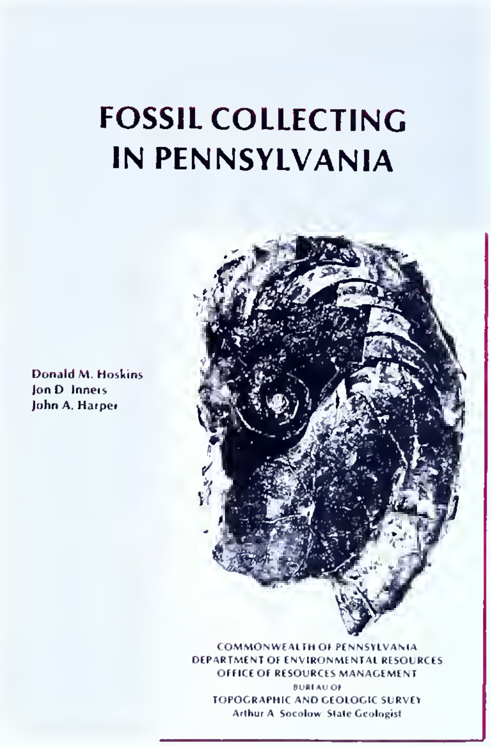
PREPARED IN COOPERATION WITH
KEYSTONE TRAILS ASSOCIATION

Anyone hiking along the Appalachian Trail in Pennsylvania will now be better able to enjoy and understand its scenic wonders. The Department of Environmental Resources' Bureau of Topographic and Geologic Survey has announced a new publication on the Geology of the Appalachian Trail in Pennsylvania. Prepared in cooperation with the Keystone Trails Association, it is a hiker's guide to geology in the vicinity of the Trail across southeastern Pennsylvania. The book contains 120 pages of description written for all of those who are interested in the natural world of mountains, valleys, water gaps, streams, mineral resources and geologic history. It is accompanied by a folded, full-color geologic map at a scale of 1:250,000 so that the hiker may identify the rock formations as he proceeds along the Trail.

A general geologic discussion of the Trail from Delaware Water Gap to Pen Mar is followed by detailed discussion of 40 sites of geologic interest along the route which are illustrated by photographs, cross sections and geologic sketch maps. The description of those sites in readily understood, non-technical language will make a hike along the Trail a more meaningful experience.

Bulletin G 74, **Geology of the Appalachian Trail in Pennsylvania** by John P. Wilshusen, is available from the State Book Store, Room G 56 South Office Building (Capitol Complex), Harrisburg or by mail at P.O. Box 1365, Harrisburg, PA 17105 at a cost of $3.20 (plus 20 cents tax for Pennsylvania residents). Checks must accompany orders and be made payable to the Commonwealth of Pennsylvania.

Finding fossils in Pennsylvania



FOSSIL COLLECTING
IN PENNSYLVANIA

Donald M. Hoskins
Jon D Inners
John A. Harper

COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF ENVIRONMENTAL RESOURCES
OFFICE OF RESOURCES MANAGEMENT
BUREAU OF
TOPOGRAPHIC AND GEOLOGIC SURVEY
Arthur A Socolow State Geologist

Where in Pennsylvania can you go and be assured of finding lots of fossils, the traces of animal and plant life that lived in the seas and swamps of our Commonwealth hundreds of millions of years ago? The answer is found in Fossil Collecting in Pennsylvania, which has been issued as a guide for the thousands of Pennsylvanians and visitors to Pennsylvania, young and old, professionals and amateurs, who relish the outdoor experience of searching for, finding, and extracting those relicts of ancient life.

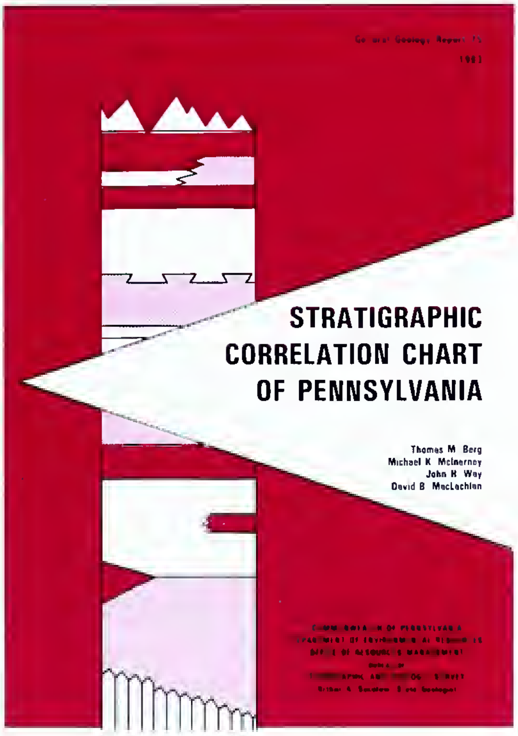
The new, third edition of Fossil Collecting in Pennsylvania, published by the Bureau of Topographic and Geologic Survey of the Department of Environmental Resources, has been completely updated and revised from the earlier editions. Of the 55 fossil localities described in detail, 33 new sites are identified for the first time. The authors, Pa. Geologic Survey geologists Drs. Donald Hoskins, Jon Inners, and John Harper, visited each of the sites in 53 counties to assure access, prepare new location maps, and to describe in detail the available fossil and the geological setting. New drawings were prepared showing examples of the fossils at each locality. Previously recorded sites which had developed access restrictions or fossil depletions were eliminated from the listing.

The introductory chapters were revised and a new section added dealing with "trace" fossils, the tracks and trails of fossils.

The new, 215-page 3rd edition of Fossil Collecting in Pennsylvania, replete with illustrations, photographs, and location maps, is a worthy successor to the original edition. This book has annually been a "best seller", over 15,000 copies have been sold since it was first issued in 1964.

Fossil Collecting in Pennsylvania, General Geology Report 40, 3rd Edition, is available from the State Book Store, Rm G-56 South Office Building, Harrisburg, or by mail, State Book Store, P.O. Box 1365, Harrisburg, PA 17105. The price is $3.20 (plus 20¢ tax for Pa. residents), enclose check payable to Commonwealth of Pennsylvania.

Stratigraphic Correlation Chart of Pennsylvania



STRATIGRAPHIC CORRELATION CHART OF PENNSYLVANIA

Thomas M. Berg
Michael K. McInerney
John H. Way
David B. MacLachlan

To show the relationships of the position and age of origin of each of over 400 named rock units (group formations and members) in Pennsylvania, a correlation chart has been prepared and published by the Bureau of Topographic and Geologic Survey of the Department of Environmental Resources. This is the first such total correlation chart ever prepared for Pennsylvania.

Utilizing 15 vertical columns to represent the units of 15 geologically distinct localities in Pennsylvania, the rock names are placed in sequence according to their age of origin and their actual vertical sequence of occurrence in the field. The appropriate geologic time units (eras, periods) and time-stratigraphic units (systems, series, and stages) are given on the chart, as well as the chronological ages in millions of years before present. It is therefore possible not only to determine the geologic age of each rock unit and its relative position at each area of the state, but also to compare and relate its age and position to any other rock unit in the state; thus the name "Correlation Chart."

The "Stratigraphic Correlation Chart" will be of extensive use to all who are engaged in geological exploration, development, and research in Pennsylvania. This includes those in the coal, oil and gas, and other mineral industries. The **Stratigraphic Correlation Chart of Pennsylvania** was authored by T. M. Berg, J. H. Way, Jr., and D. B. MacLachlan of the State Geologic Survey, and M. K. McInerney, formerly with the Survey. It is available at the State Book Store, P.O. Box 1365, Harrisburg, PA 17105. The price is $4.20 (plus 26¢ tax for Pa. residents). Enclose check payable to Commonwealth of Pennsylvania.

Summary of the Slate Industry In Pennsylvania, 1983

by S. W. Berkheiser, Jr.
Pennsylvania Geological Survey

Introduction

The slate industry of Lehigh and Northampton counties, Pennsylvania, is alive and well, while the Peach Bottom district remains idle. The industry in Lehigh and Northampton counties has been restructured in recent years and currently produces about $4 million worth of slate products annually (Kebblish and Tuchman, 1981), including roofing, billard, blackboard, electrical, and structural slates.

Although production in terms of total tonnage has declined in the past decade, value has been increasing steadily as the U.S. luxury trade trends away from synthetics and toward increased restoration work. Recent, large brush fires in the western states have resulted in a demand for roofing slate. One Pennsylvania producer reports a 9-month backlog of orders for roofing slate. Demand for various slate products is cyclic and flexibility in mining, milling, and marketing is a key to survival.

Lehigh-Northampton District

Only three known concerns are mining slate in the Commonwealth (Lee, personnel communication, 1983). Their market area generally includes the continental United States. The largest producer is Anthony Dally and Sons, Inc., with five operating quarries and at least three active supporting mills in the Penn Argyl district. It is the only company in the United States producing billard and electrical slates. The Penn Big Bed Slate Company produces slate from one pit north of Slatedale and has an associated mill which manufactures roofing, structural, and blackboard slates. A third and smaller producer in Wind Gap does business on an intermittent basis.

The Dally and Penn Big Bed enterprises are under the enthusiastic marketing arm of the Structural Slate Company. According to their general manager, Mr. John Lee, one of the apparent reasons for Pennsylvania's blue-gray slate success is economics. Red-roofing slates from Vermont cost about $1,200 per square (725 lbs.) and gray from Vermont about $225 per square whereas Pennsylvania slate averages about $120 per square.* Thus, Pennsylvania producers have a competitive advantage.

Little has changed with respect to mining and milling of slate since the turn of the century. The Pennsylvania slate industry is labor intensive and at present directly employs about 200 people (Lee, personnel communication, 1983). Channeling machines, used for recovering rough blocks of slate from the quarry, were replaced by wire saws in the early 1930's but the former are still used in freezing weather. The only other major change is in the method of disposal of waste slate. Traditionally, this material was piled up and formed huge dumps in the producing areas. Today, most of this waste material (up to 85% of the total amount quarried) is dumped into nearby, typically adjacent abandoned quarry holes.

In an effort to use the waste, some innovative ideas have been proposed and occasionally tried, such as lightweight aggregate, ashlar type dimension stone, mineral fillers, roofing granules, fenceposts, mineral wool, slate-lime building blocks, etc. But in general, for one reason or another, none of these have proven to be a long-term success.

Two grades of slate are mined: clear and ribbon. The clear stock (known as "big beds") is the most desirable. It is characterized by a lack of sandy laminations and has a uniform, gray appearance. Ribbon stock is distinguished by darker, sandy laminations which show up as the slaty cleavage cuts across the sedimentary layers. Clear "runs" in the western part of the district reach true bed thicknesses of up to 30 ft, but generally average about half of that amount. Clear "runs" in the eastern part of the district are generally thinner. Mr. Lee stated that the three remaining operators survived

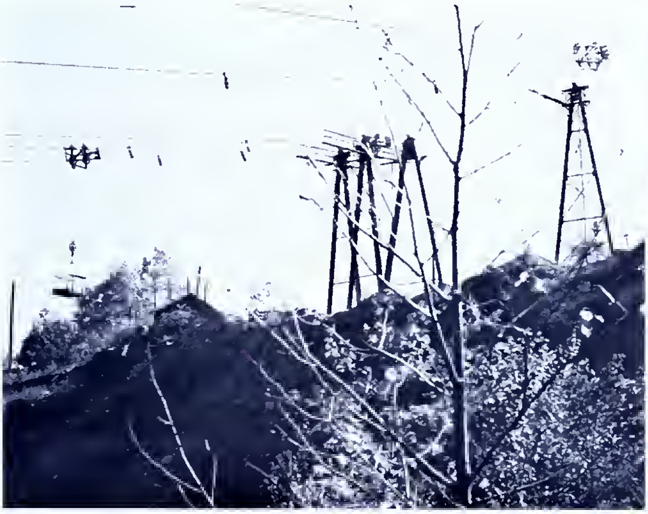


Figure 1. Typical hoisting system used in the Lehigh-Northampton slate district. Engine and drum houses are to the right of the photograph. Penn Big Bed Co., Slatedale, Pennsylvania.

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*One square equals the slate necessary to cover 100 sq. ft. with a 3-inch overlap. Standard thickness is 3/16 inch.

because they were, in part, mining "big beds" or clear stock which is used almost exclusively for billard, electrical and blackboard slates. Clear slate blocks of up to 7 tons can be recovered. This limit is based more on the capabilities of the hoisting equipment (Figure 1) rather than the potential dimensions of the recoverable material.

Axial-plane cleavage generally prevails throughout the Martinsburg Formation terrain (Figure 2). The cleavage is also the plane along which the slate splits and is mined. Long "runs" in the "big beds" may be expected when the cleavage is subparallel to bedding, as in the limbs of anticlines or synclines. Because the cleavage plane forms the floor of the quarries, it is desirable to mine a recumbant, isoclinally folded syncline or anticline that will give the quarry a flat, safe floor. Conjugate joint sets sometimes can be used for one or more of the vertical faces of a quarry oriented subparallel or parallel to strike. It should be noted that these slate quarries are unique in that they are generally square to rectangular, with vertical faces developed to a depth of a maximum of about 850 ft (Figure 3). Lifts are typically 12 ft high with ½ ft or less of offset. Falling ice in winter is a hazard to the quarry workers below. Daily removal of icicles consists of excellent marksmanship and occasional black powder charges for a particularly stubborn buildup.

Most producers have at least a 50-year reserve at current production rates. As a general rule of thumb, in a year's time a typical quarry will mine a "drift" which generally consists of a 12 ft thick by 170 ft x 100 ft wide volume of slate. A new quarry site merely involves moving along strike adjacent to one of the 400 or so abandoned quarries having the desirable characterisitcs needed. Total potential reserves for the Lehigh-Northampton area are enormous.

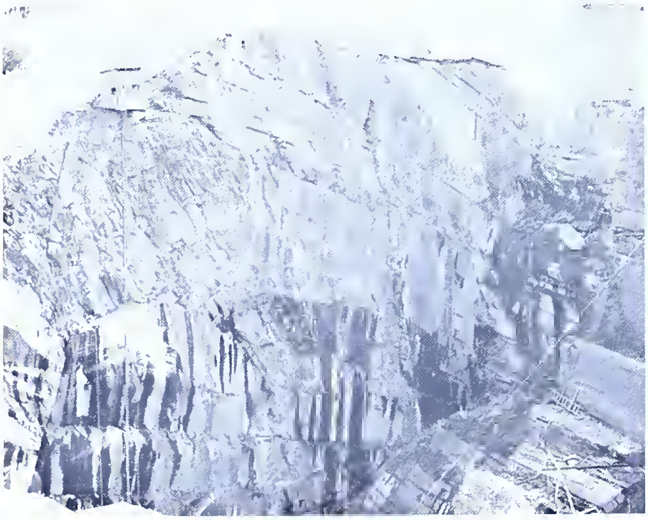

Figure 2. East face of adjacent abandoned quarry showing south-dipping overturned anticline with axial plane cleavage. The base of a "big bed long run" starts near the roof of the signal shanty. A prominent joint showing minor offset between beds forms the "back" face.

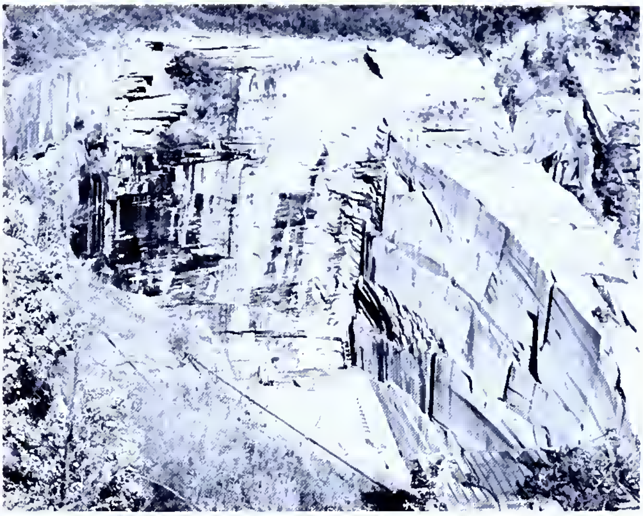

Figure 3. View looking north into active quarry. Note vertical faces. Bedding is near vertical (note ribbons on east face), quarry floor dips N30°S (axial plane cleavage). A prominent joint is used for the "front" face. Quarry is developed to a depth of about 100 ft below ground level.

Peach Bottom District

The mining of slate in the Peach Bottom district of York and Lancaster counties dates back to the late 1700's. Joseph Hewes, a signer of the Declaration of Independence, is reported to have laid the oldest known slate roof in the area (Behre, 1933). Behre also reports that the roofing slate from this district has been described as unquestionably one of the best in the world and was awarded the highest premium at the Crystal Palace exposition in England in 1850. However, the characteristics that make this hard slate so valued as a roofing material also led to the demise of the district. Its moderate metamorphic grade and hardness limit its uses. The difficulty and expense of milling can not compete with other districts.

The intermittent slate industry production in this district has been defunct since about the late 1960's. Behre reports no production activity in 1933. However, the Funkhouser quarry (developed along strike for about 4500 ft) was worked for roofing slates sometime between 1933 and the late 1950's. Ruberoid Company produced ground slate products here in 1962. It is believed that GAF Corp. stopped producing roofing granules at this site prior to 1969.

Conclusions

The mining and milling of slate in Pennsylvania is steeped with tradition. No two pieces of roofing slate are exactly alike. The pride of craftsmanship is exhibited in every hand finished product. The quarry faces themselves have a unique rhythmic, hand-crafted finish. Pennsylvania continues to be a leading producer of traditional as well as new slate products.

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Behre, C. H., Jr. (1933), *Slate in Pennsylvania,* Pennsylvania Geological Survey, 4th ser., Mineral Resources Report 16, 400 p.

Kebblish, W. and Tuchman, R. J. (1933), *The Mineral Industry of Pennsylvania in 1981,* Pennsylvania Geological Survey, 4th ser., Information Circular 92, p. 11.

SURVEY ANNOUNCEMENTS

York Mineral Show

The York Rock & Mineral Club will hold its Fifteenth Annual Mineral & Gem Show on Saturday, April 7, and Sunday, April 8, 1984 at the Alert Fire Company Hall, Emigsville, Pennsylvania (Rt. 181 North of York).

Show hours are: April 7, 10 a.m. to 7 p.m.; April 8, 10 a.m. to 5 p.m.

Admission will be: $1.00 per person, children 12 and under — Free

For further information contact Show Chairman, Ken Kauffman, 747 Florida Avenue, York, PA. 17404.

U. S. Geological Survey Increases Map Prices Effective January 1, 1984.

The U. S. Geological Survey has increased the prices for all map series. The prices of the maps most often requested are listed.

Standard Topographic Maps	1:24,000	$2.25
County Maps	1:50,000	3.60
30 x 60-minute maps	1:100,000	3.60
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New Survey Publications

Enjoy the Geology at Samuel S. Lewis State Park, York County

Visitors to the Samuel S. Lewis State Park area in eastern York County (near Wrightsville) can look forward to increasing the pleasures of their outing, thanks to a new geologic park guide issued by the Bureau of Topographic and Geologic Survey. Park Guide 17, "Samuel S. Lewis State Park," authored by Survey staff geologist Dr. Jon D. Inners, describes the visible geologic features of the area and how they came into being. Illustrations and diagrams in the brochure help to better comprehend the unusual features which the visitor will encounter.

Park Guide 17 is available at no charge at the Samuel S. Lewis State Park, or upon request from the Bureau of Topographic & Geologic Survey, P.O. Box 2357, Harrisburg, PA 17120.

Report On Carbonate Whiting Sources

A basic mineral resource used in a wide variety of industrial products has been studied by The Department of Environment Resources' Bureau of Topographic and Geologic Survey and found to be available at a number of locations in southeastern Pennsylvania. The results of the geologic investigations have been released in Mineral Resources Report 83, entitled **Reconnaissance Survey of Potential Carbonate Whiting Sources in Pennsylvania.** Investigated and reported by Survey economic geologic Samuel W. Berkheiser, Jr., the 53-page report provides data on chemical and physical properties (including whiteness and brightness values) of white carbonate rocks at 14 locations in Adams, Chester, Cumberland, and York Counties.

In pulverized form this mineral matter is used in such diverse products as plastics, paints, adhesives, rubber, joint fillers, and paper coatings and fillers.

This report should be of interest to mineral developers and to many industrial operators who are in need of this raw material close to their manufacturing plants here in the east.

Report M 83, **Reconnaissance Survey of Potential Carbonate Whiting Sources in Pennsylvania** is available from the State Book Store, P.O. Box 1365, Harrisburg, PA 17105. The price is $3.70 (plus 23¢ tax for Pa. residents); enclose check or money order payable to Commonwealth of Pennsylvania.

25 Years with the State Survey

Assistant State Geologist Donald M. Hoskins' 25 years of service to the Bureau of Topographic and Geologic Survey was recently recognized by his colleagues with a surprise celebration.

Don Hoskins began his duties with the Survey as a field geologist on November 13, 1956 when the Survey was still under the Department of Internal Affairs. Don worked on mapping the Mifflintown 15′ quadrangle in one of the most geologically complex areas of the Appalachians; the resulting map and report are widely recognized as an outstanding example of modern geological investigation and interpretation.

After a period of educational leave to acquire his doctorate degree at Bryn Mawr College, Hoskins returned to mapping and was appointed chief of the Geologic Mapping Division. Subsequently he served a stint as the Survey's Geologic Editor until he was appointed Assistant State Geologist in 1968.

In addition to two major geologic atlas reports, Don Hoskins has to his credit one of the Survey's best sellers, Fossil Collecting in Pennsylvania, a bulletin now in its 3rd edition. His geologic Park Guide on Gifford Pinchot State Park in York County is also extensively used and appreciated by the public.

Don Hoskins has made a major contribution to the Survey's geologic achievements and as Assistant State Geologist has been of great service in coping with the Survey's administrative needs. His colleagues and the geologic community salute his 25 years of achievement with the Survey.

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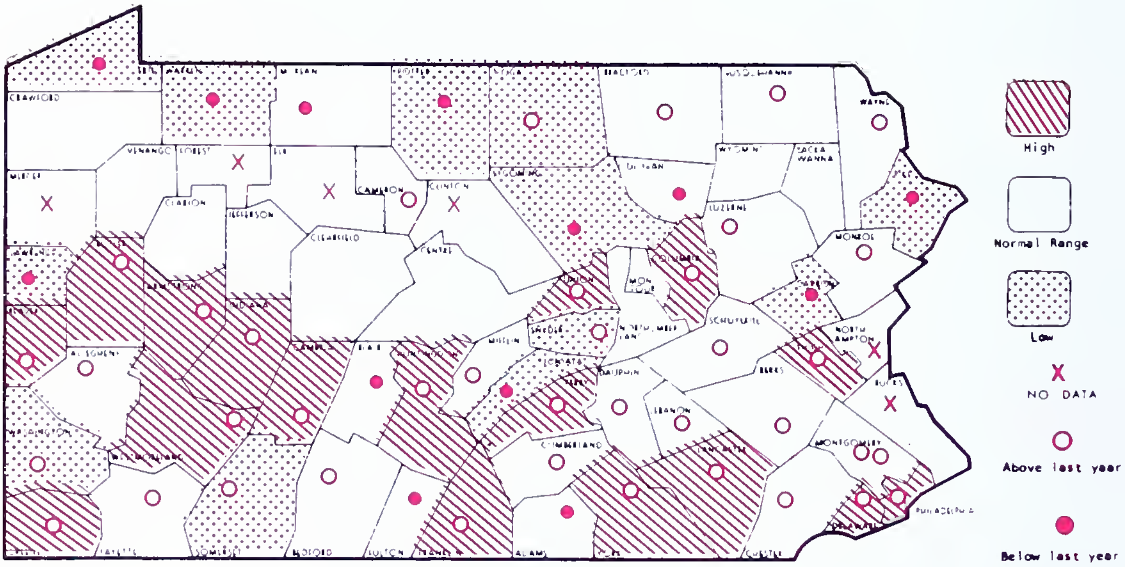

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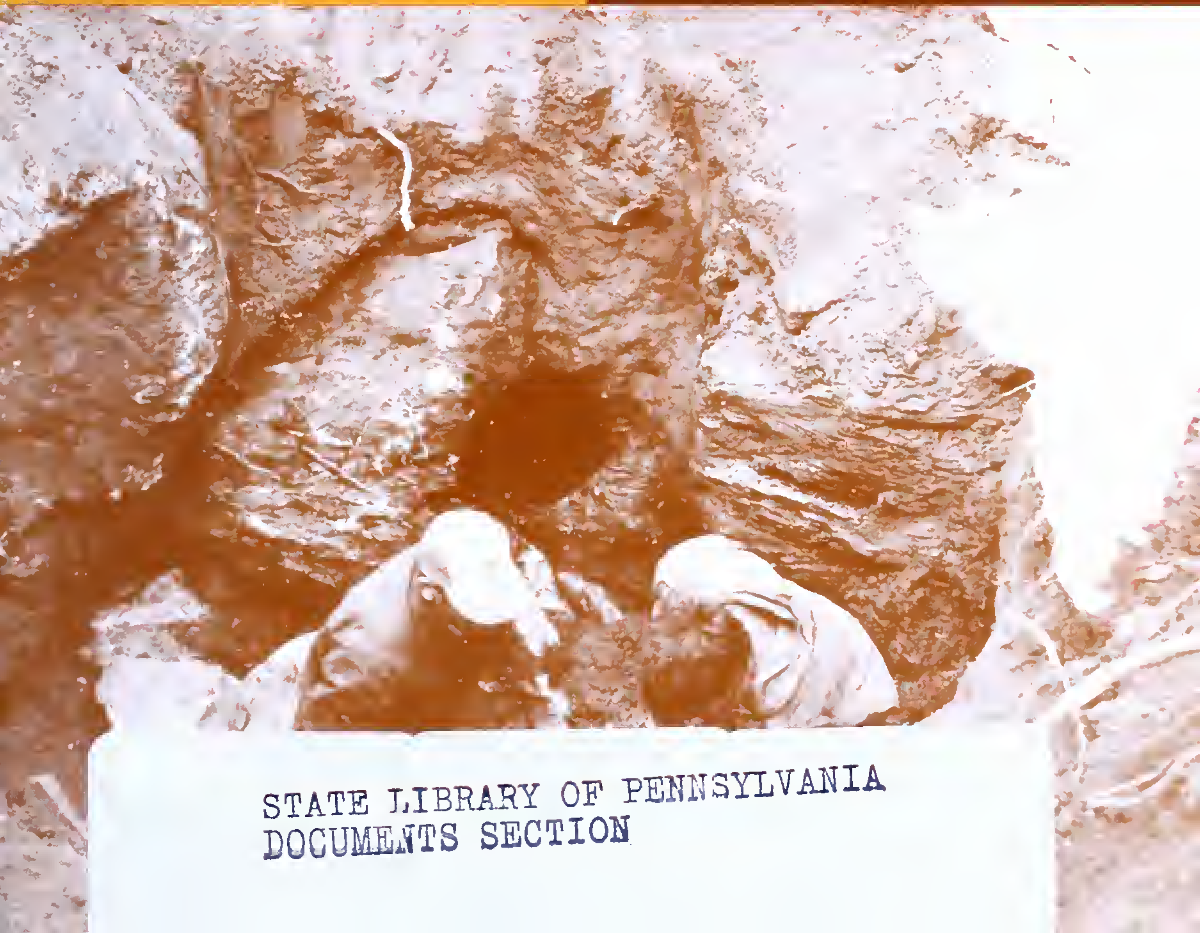

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ON THE COVER: View into 15 foot deep excavated sinkhole in Conestoga limestone, Millersville Borough, Lancaster County. Open "throat" which caused the surface collapse is shown in center of photo. Story page 15-16. Photo courtesy of J. P. Wilshusen.

PENNSYLVANIA GEOLOGY is published bimonthy by the Topographic and Geologic Survey, Pennsylvania Dept. of Environmental Resources, Harrisburg, Pennsylvania, 17120.

Editor, Arthur A. Socolow; Associate Editor, Donald M. Hoskins.

Articles may be reprinted from this magazine if credit is given to the Topographic and Geologic Survey.

VOL. 15, NO. 2 **APRIL, 1984**

FROM THE DESK
OF THE
STATE GEOLOGIST

ENVIRONMENTAL IMPACTS — NOT ALWAYS BAD

It is commonly assumed these days that when man modifies the environment it is harmful, while nature's treatment of the environment is generally presumed to be proper and beneficial. But is that really always the case?

Strip-mining laws in many states require the land surface to be restored to original, natural slope or contour. Yet the original slope in many instances was one that was fairly steep and subject to rapid erosion and gullying action. Long ago the Far East learned that terraced slopes resulted in less erosion and more arable, workable lands than natural, inclined slopes. Thus man, when permitted, can create less wasteful and more usable slopes than nature.

Eastern Pennsylvania has had two lessons in recent years of major streams that had benefited from man's activities. These streams had acquired year-round, uniform flow characteristics as they received fresh, pumped water from nearby mining operations, a quarry in one case and a deep mine in the other instance. A stable fish population had developed in the streams, capable of supporting sport fishing. Then, as the mines closed down for economic reasons and the pumping to the streams ceased, the streams have reverted back to their extreme seasonal flow variations, too low in the summer to support a significant fish population, or even to maintain a water quality sufficient for the human consumption which had developed during the augmented flow era.

And even as it becomes more and more difficult to build any major dams along our nation's rivers for fear of adverse environmental impact, we are losing the flood control and recreational benefits from the impoundments provided by dams. As many of us know from personal experience, floods are devastating natural phenomena. If man is capable of mitigating the destruction of floods, including the vast tonnages of soil and farmland which are washed away by such natural events, then it should be recognized that man's dam construction efforts may merit favorable consideration, rather than "knee-jerk" negative responses.

Before I am inundated by shrieks of horror and examples of man's inexcusable mayhem upon nature, permit me to stress that I do not support nor encourage an unrestrained assault upon nature's wonderlands and processes. I simply wish to note that nature is not always kind nor the best engineer. There are times when man can improve on nature. In the biological field we see it in man's attempts to deal with pestilence and deformities. In the meteorological world we try to cope with hurricanes, blizzards, droughts, and heat waves. And in the world of geology and hydrology, we should try to mitigate the affects of erosion, flooding, earthquakes, landslides, etc. We may not be able to stop those phenomena, but when permitted to do so, we can design procedures and structures that will limit the costly and harmful impacts of some of nature's processes. It is well to keep in mind that not all of man's impacts on the environment are harmful.

Arthur A. Socolow

What Does It Take To Make A Brick? The Watsontown Story

by S. W. Berkheiser, Jr. and J. D. Inners
Pennsylvania Geological Survey

For more than 75 years, the community of Watsontown on the West Branch of the Susquehanna River in Northumberland County has been involved in brickmaking. At the present time two companies, Watsontown Brick Co. and Glen-Gery Corp., operate brick plants and complementary shale pits in the area (Fig. 1). Watsontown Brick Co. is a family-owned business established by Charles E. Fisher, Sr., in 1908, one mile south of town. Glen-Gery Corp., one of the largest brick manufacturers in Pennsylvania, acquired their plant and quarries from Keystone Brick Company in the mid 1940's, and has operated continuously at the north edge of Watsontown since that time. Combined, these two businesses employ approximately 125 people and are capable of producing more than 150,000 bricks per day.

Watsontown owes much of its importance as a brick-manufacturing center to its favorable geologic location. Several Silurian age shale formations in the area provide good raw materials for making brick, and folds in the area cause repetition and broadening of the outcrop belts of these formations (Fig. 1).

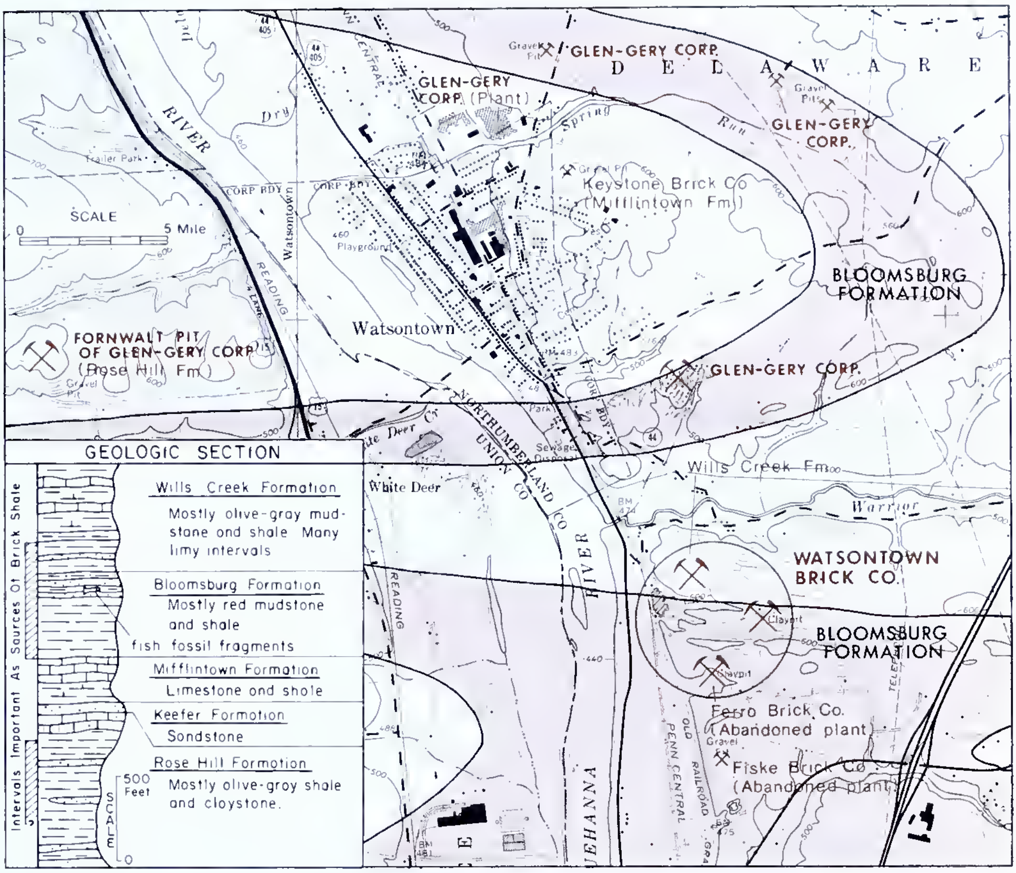

Figure 1. Simplified geologic map and section of Watsontown area, showing outcrop of Bloomsburg Formation, active (large symbols) and abandoned (small symbols) shale quarries and location of old and current brick works. (Geology from Inners, in preparation)

The Bloomsburg Formation, the principal source of brickmaking material, originated as a fine-grained, red mud that was rapidly deposited in a shallow, brackish water embayment or lagoon approximately 410 million years ago (Hoskins, 1961). In marked contrast to most red-bed sequences in the state, the Bloomsburg of central Pennsylvania contains abundant vertebrate and invertebrate fossil remains, including fragments of head shields of extinct cyathaspid fish, which were recently discovered in the Watsontown Brick Co. quarry (Hoskins, 1983). Less important sources of brick shale, but still extensively quarried, are the Rose Hill and Wills Creek Formations. Olive-colored shales from these two formations are blended as needed with the red Bloomsburg mudstones to improve plasticity. Watsontown Brick Co. presently mines shale (principally the Bloomsburg) at the rate of about 150 tons per day to feed a new kiln, which has a capacity of 70,000 to 80,000 bricks per day. A cored, standard-size brick (2¼″ by 3½″ by 8″) requires about four pounds of raw material.

In order to better understand the process of brick manufacture, let us follow a brick through the Watsontown Brick Co. plant (Fig. 2) from its origin as a "block" of newly quarried Bloomsburg mudstone to the point that it emerges as a finished product, stacked and ready to be transported to the consumer (Fig. 3).

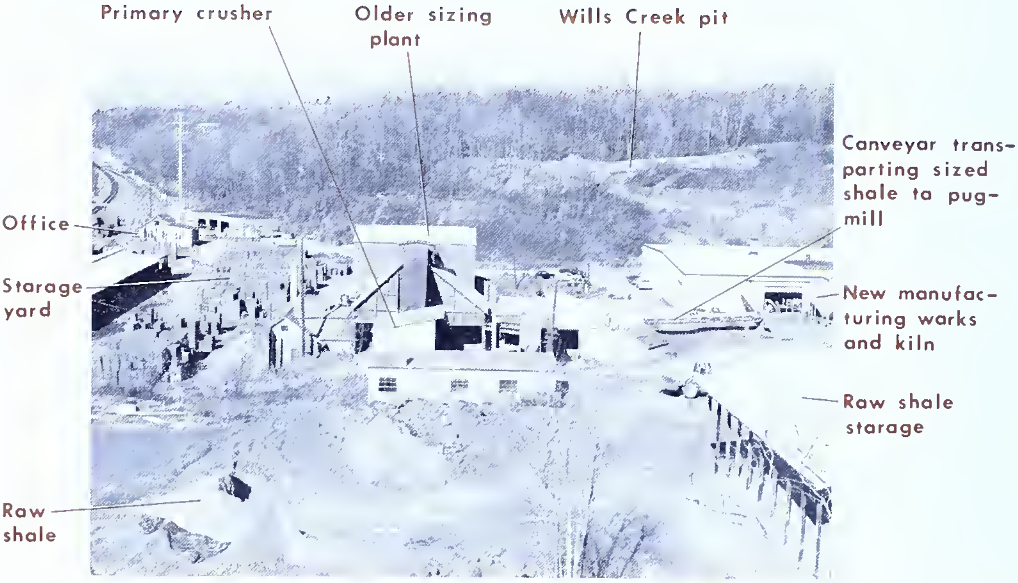

Figure 2. View of Watsontown Brick Company operation from the ridge south of the plant looking north.

After excavation and haulage to the plant, the mudstone is stockpiled. From the stockpile it goes to the first stop in its transformation from mudstone to brick, the primary roller crusher. The material is further reduced to about -25 mesh (0.028 inches) in a series of dry pans (roller-type crushers). This is followed by screening to obtain the proper gradation for ease of manufacturing and producing a sound product.

A pug mill (bladed screw-type machine used for mixing water and clay) is automatically fed with the shale-mix, water, and an additive to enhance green strength (strength of unfired brick) and workability. From the pug mill, the shale-mix is extruded like toothpaste onto a conveyer belt. The die through which the shale-mix is extruded controls the size and surface texture of the brick being manufactured. Additional surface coatings, such as sand, can be added before the extruded column is cut into slugs by a guillotine cutter. The slugs are then conveyed to the computerized setting machine which automatically cuts, stacks, and loads the green brick onto the kiln cars. Each kiln car contains 6,000 standard-size bricks stacked 12 high. The computerized journey through the dryer takes

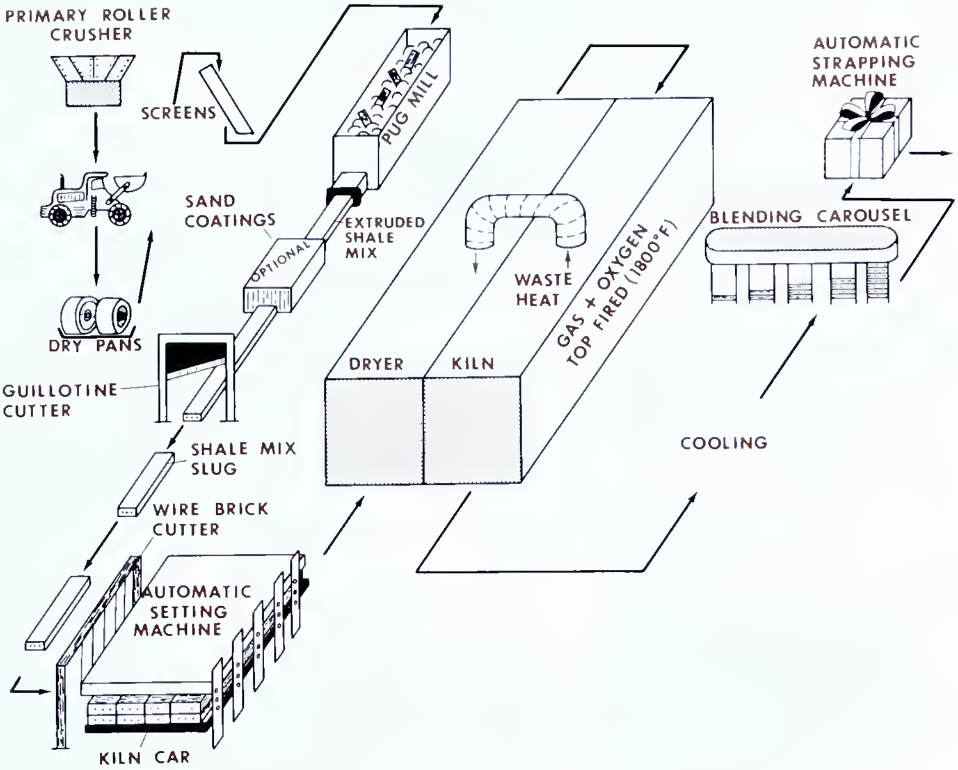

Figure 3. Simplified flow chart of the brick making process at Watsontown Brick Co., Watsontown, Pennsylvania.

about 1½ days. The dryer uses waste heat from the adjacent tunnel kiln to dry the bricks prior to firing (each brick loses about 14 oz. of water). Firing in the kiln is accomplished at a temperature of about 1800°F and takes about two days. The kiln is presently fueled by a mixture of natural gas and oxygen. Oil is a standby fuel, and provisions for coal use were incorporated into the design. Flashing (coloring of the brick in an oxygen-poor atmosphere) is done in the tunnel kiln and is generally restricted to one side of the kiln and to one or two rows of cubes on a kiln-car. A cube equals 500 standard size bricks. Kiln-cars are moved automatically through the dryer, tunnel kiln, and unloading stations. Mixing of the flashed bricks with the more abundant unflashed bricks is semi-automatic with men unloading the bricks from the kiln-car to a monorail carousel which feeds an automatic strapping machine.

In the early 1950's, Watsontown Brick produced about 70,000 to 80,000 bricks per day in 12 coal-fired periodic kilns (4 beehives, 8 rectangulars), and employed 112 people. Today the same production is achieved using 1 tunnel kiln and 30 people. The operation is also much more energy efficient. Watsontown Brick's efficiency is readily apparent from the size of their market which includes such places as Detroit, Chicago, Baltimore, Washington, D.C., Virginia, North Carolina (a major U.S. producer of bricks) and Canada, as well as the entire northeastern United States.

Initially, paving bricks were the main product made at Watsontown, and these helped surrounding communities keep their streets free of mud. Present products are for home and commercial construction. Adjusting to changing end-uses, manufacturing techniques, energy sources, and economic cycles, has helped the community of Watsontown and Pennsylvania to remain a major supplier of quality industrial mineral products.

We gratefully acknowledge the cooperation and information provided by Charles E. Fisher, Watsontown Brick Company and Jon R. Moyer, Glen-Gery Corporation.

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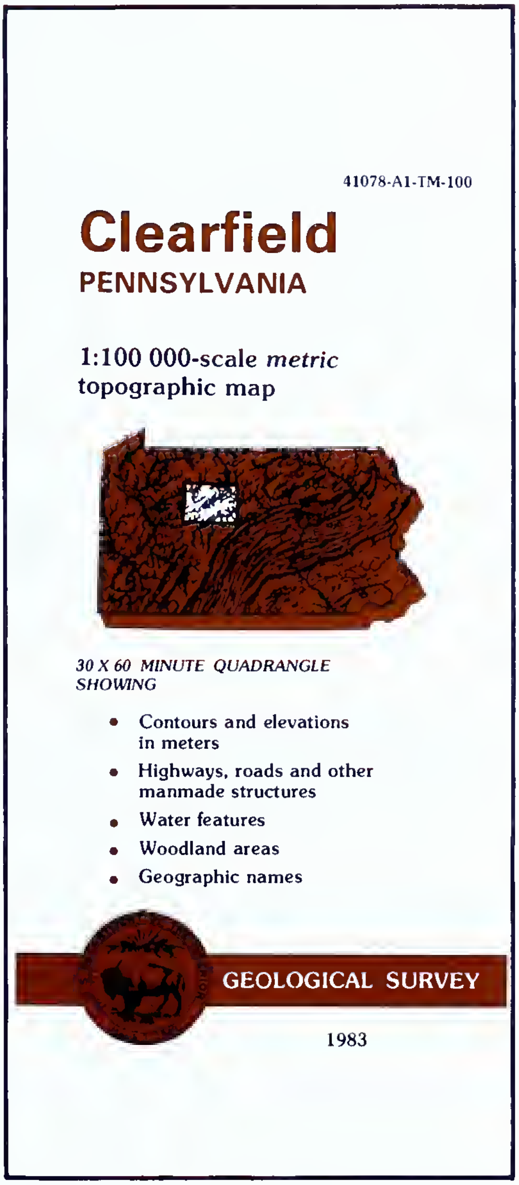
U.S.G.S. Issues New 1:100,000 Scale Metric Topographic Maps

The most familiar topographic map series produced by the U.S. Geological Survey is the 7.5-minute quadrangle. This series of maps meets many of the requirements users of cartographic materials have. However, there is an increasing need for maps at smaller scales, covering larger areas than the 7.5-minute quadrangle.

To meet this need the U.S. Geological Survey has introduced a 30 x 60-minute topographic quadrangle map series which is derived from the 7.5-minute maps. The scale of these maps is 1:100,000. (1 centimeter on the map equals 1 kilometer on the ground or about 1.6 miles) The elevation contours are produced in metric units with contour intervals of 20 meters. The maps are multicolored, show political boundaries, highways, manmade structures, and topographic and cultural features. Another feature of this series of maps is a full fine-line Universal Transverse Mercator grid. The map legend includes a conversion table for the metric system, declination diagrams for grid convergence, and a chart of topographic map symbols. The 1:100,000 scale quadrangle maps provide much of the detail shown on larger scale maps yet cover enough geographic area to be useful as base maps for regional studies.



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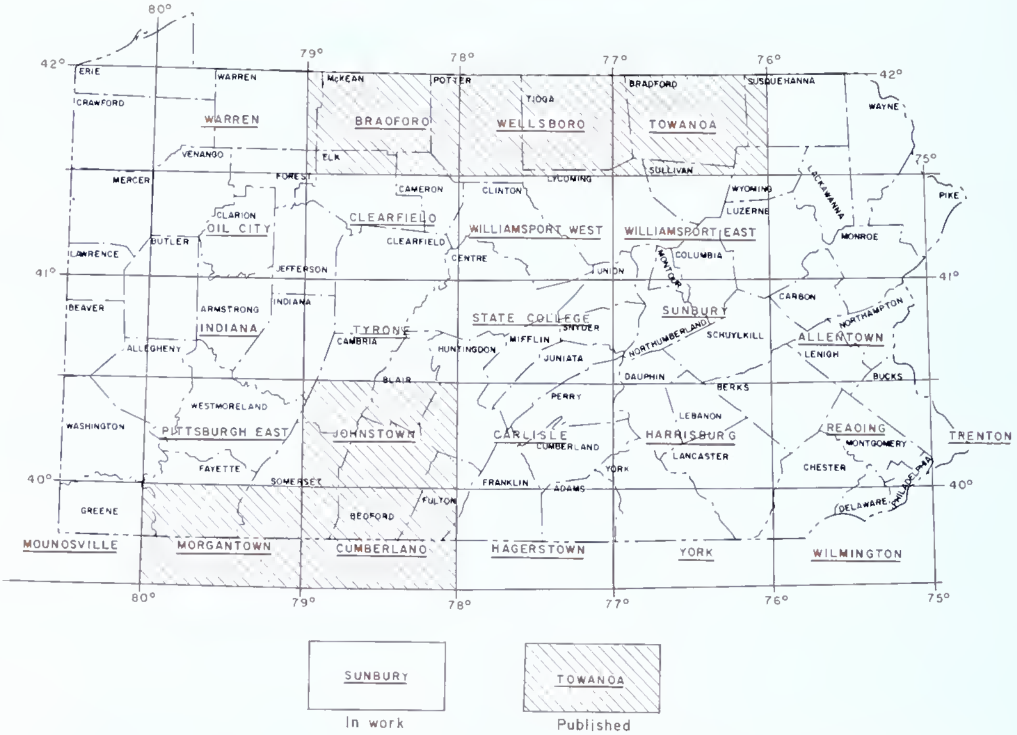
GEOLOGICAL SURVEY

1983

Six maps in this series are completed for Pennsylvania. They include: Bradford, Wellsboro, and Towanda in the north, and Johnstown, Morgantown, and Cumberland in the south.



Published maps are available at $3.60 each from Washington Distribution Section, U.S. Geological Survey, 1200 South Eads Street, Arlington, Virginia 22202.

GEOLOGY TEACHERS TO MEET

The Eastern Section of the National Association of Geology Teachers will hold its annual spring conference April 26-29, 1984, at Lewes, Delaware at the Virden Center of the University of Delaware Marine Science Center. Registration will begin at 4 p.m. on April 26; workshops are scheduled April 27; field trips and banquet April 28. For fees and options contact Ellis Underkoffler, Talley Jr. High, 1110 Cypress Rd., Wilmington, DE 19810; phone, office: 302-792-3978. home: 302-762-5837.

FRANKLIN COUNTY MINERAL SHOW

The Franklin County Rock and Mineral Club is sponsoring their seventh annual show, May 12 and 13, 1984, at the Chambersburg Middle School, McKinley Street and Stouffer Avenue, Chambersburg, Pennsylvania. The times for Saturday are 10:00 a.m. to 7:00 p.m. and on Sunday 11:00 a.m. to 5:00 p.m. For more information contact Pat Hoyer, 8810 Rowe Run Road, Shippensburg, Pennsylvania 17257; phone 717-532-6058.

Spiral feeding-organ supports preserved in the brachiopod Athyris spiriferoides (Eaton), Rockville, Dauphin County, Pennsylvania

by Jon D. Inners
Pennsylvania Geological Survey

An unexpected result of recent fieldwork aimed at up-dating General Geology Report 40, *Fossil Collecting in Pennsylvania,* was the detection of previously unrecognized paleontologic details at some "old" localities. One of the most interesting of these occurrences is at the well-known Middle Devonian fossil collecting locality at Rockville, just north of Harrisburg. What started out as a routine field check of an oft-described locality (Willard, 1939; Ellison, 1965; and Hoskins, 1969) livened considerably when the author discovered numerous specimens of the spiriferid brachiopod **Athyris spiriferoides** (Eaton) in which the spiral feeding-organ supports are preserved. These delicate internal structures are generally broken before burial or otherwise lost during diagenesis of the enclosing sediment.

The **Athyris** specimens with preserved feeding organ supports occur in an abandoned sandstone quarry in Little Mountain on the east side of the Susquehanna River at Rockville, approximately 3 miles north of Harrisburg in Dauphin County (40°20′21″N/76°54′14″W, Harrisburg West quadrangle; Figure 1). The quarry lies at the north end of a deep rock cut on U.S. Routes 22-322 and exposes vertical to slightly overturned beds belonging to the upper part of the Montebello Member of the Mahantango Formation. Most of the rock that crops out in the quarry walls is thick bedded, medium- to light-gray, medium- grained to conglomeratic quartz sandstone in which molds of large, thick-shelled brachiopods are moderately common. **Athyris** and other invertebrate fossils are very abundant in a 20-foot thick unit of medium-gray, calcareous sandy silt shale that occurs 160 feet stratigraphically below the youngest beds exposed in the quarry (Ellison, 1965). The fossiliferous bed juts out from the quarry wall at the south end of the right-of-way fence.

Athyris spiriferoides (Eaton) is a Middle Devonian articulate brachiopod characterized by a biconvex profile, a narrow hinge, and prominent, laminated growth lines on otherwise smooth valves (Figure 2). **Athyris** possessed spiral, calcareous supports (spiralia,) for the complex internal feeding organ (lophophore) (Figure 3).

Athyris in the Rockville quarry typically occurs as articulated in-

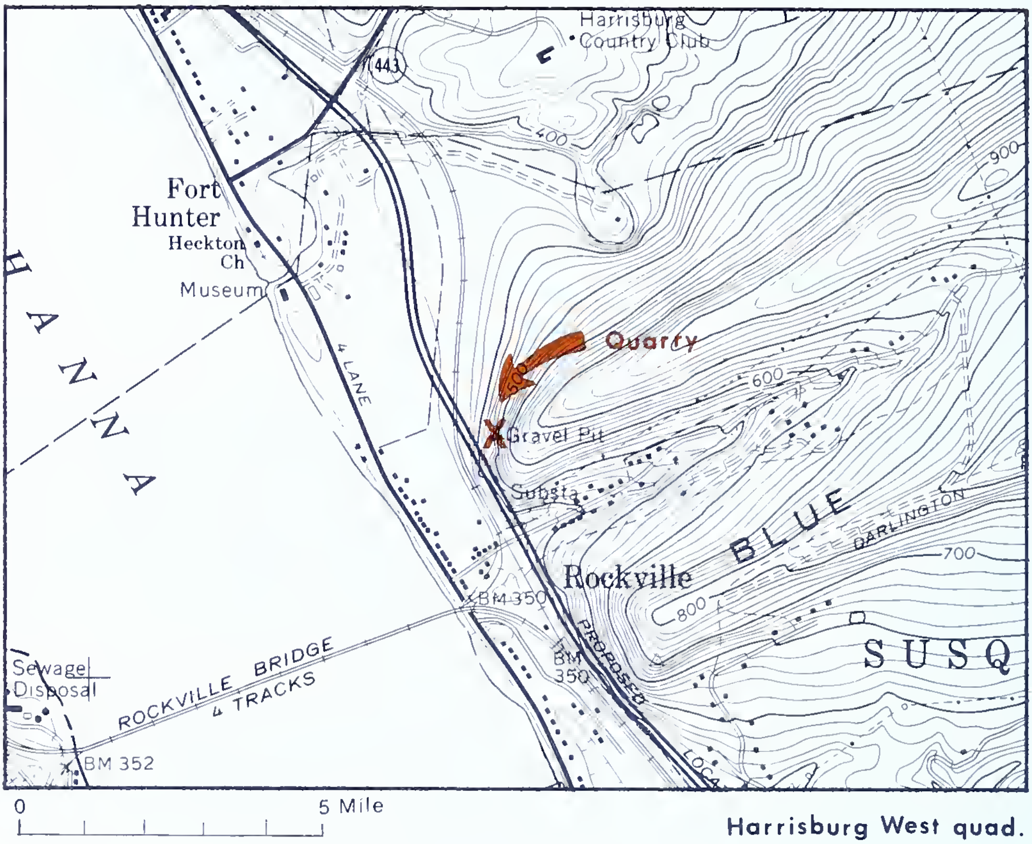


Figure 1. Location map.

dividuals (that is, the valves are connected together) concentrated on bedding planes in attitudes that appear to be only slightly disturbed from life position (Figure 4). The spiralia — readily seen in broken or abraded specimens — consist of fine ribbons of calcite embedded in the yellow- brown weathered silt that fills the space between the valves.

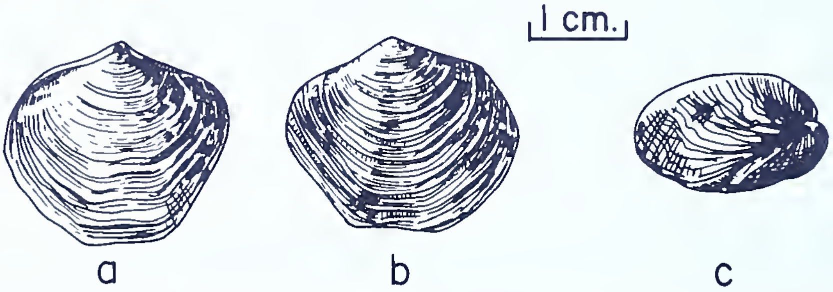


Figure 2. ***Athyris spiriferoides*** **(Eaton). Views are (a) dorsal (top), (b) ventral (bottom), and (c) side.**

Although no direct trace of the freshly lophophore itself is retained in these 387 million-year-old fossils, it is probable that the feeding-organ supported by the spiralia of **Athyris** consisted, as in some modern brachiopods, of two spirally coiled arms that diverg-

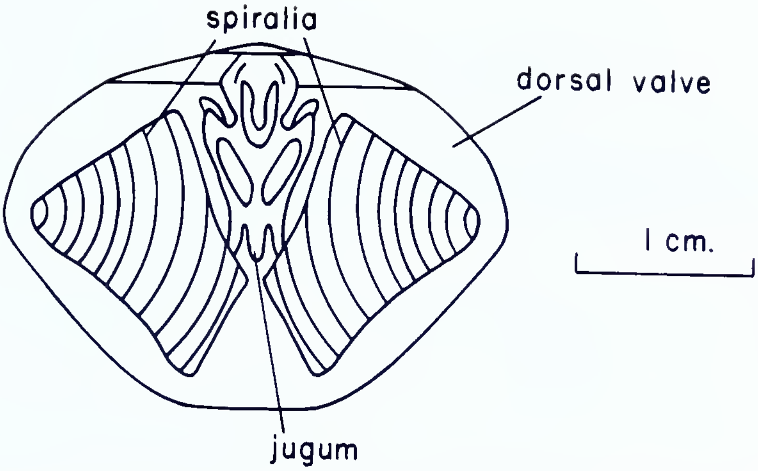


Figure 3. Interior of *Athyris*, showing structures that support the feeding organ.

ed from either side of the mouth. Each arm bore a single row of long, slender flexible filaments. On the sides of each filament were rows of hairlike-projections, or cilia. At the base of the filaments was a ciliated food groove that extended along the frontal side of each arm to the mouth.

Brachiopods are suspension-feeders; that is, they extract minute suspended food particles (microorganisms and finely divided organic material) from sea water. The basis of their feeding mechanism is the weak current stream set up by the lashing of cilia on the lophophoral filaments (Figure 5) (Rudwick, 1970). But in order to feed efficiently a brachiopod has to have some method of

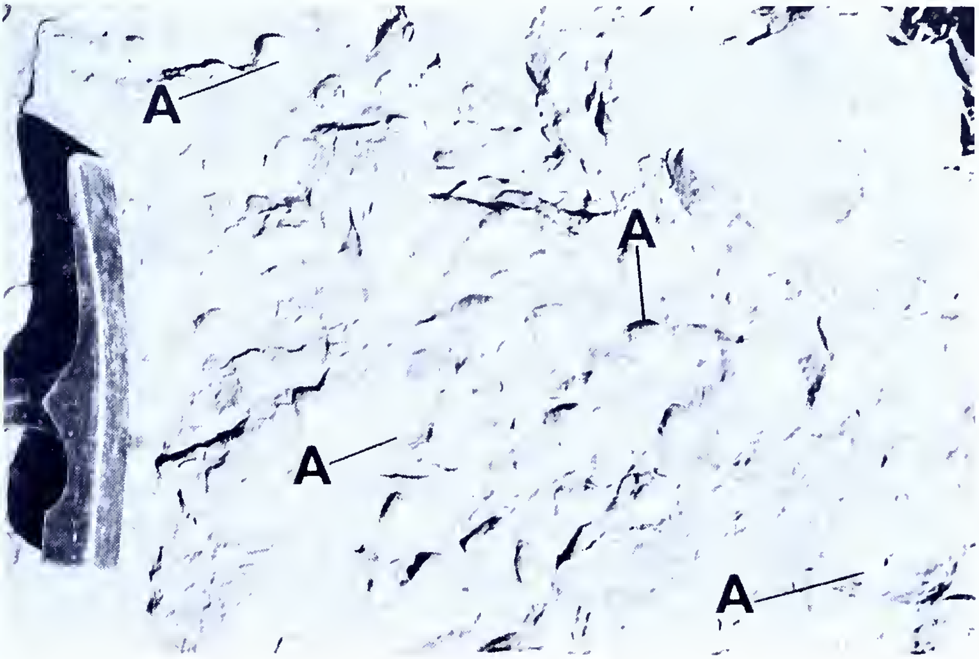


Figure 4. Slab of fossiliferous silt shale from Rockville quarry. Note abundance of *Athyris* (A).

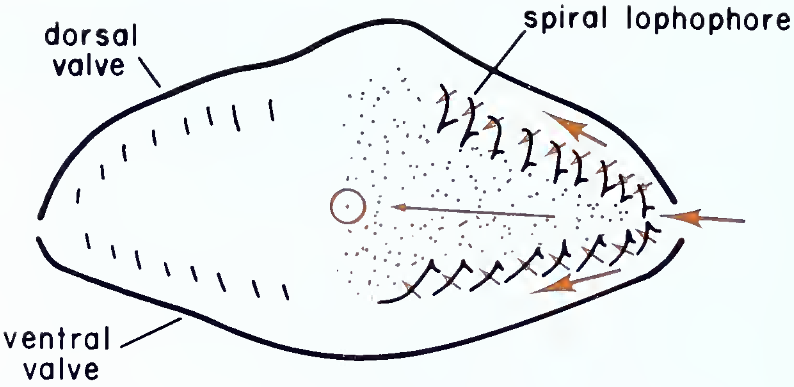


Figure 5. Generalized cross-sectional diagram of feeding mechanism of *Athyris.* (Thick arrows = inhalant currents; thin arrows = exhalant currents; strippled area = exhalant chamber; bull's eye = exhalant current issuing from medial part of gape.)
(Modified from Rudwick, 1970, p. 138).

separating incoming (or inhalant) nutrient-rich currents from outgoing (or exhalant) currents containing inorganic particles and body wastes. In the spiriferid brachiopods, this separation of inhalant and exhalant currents was accomplished by the twisting and coiling of the lophophore arms around the spiralia.

The 570-million-year history of brachiopods from Cambrian time down to the present day clearly shows the overall survival efficiency of the lophophoral feeding mechanism. Spiriferid brachiopods, however, became extinct in the Early Jurassic (about 190 million years ago), perhaps because spiralia were a less robust method of supporting a spiral lophophore than that adopted by some other brachiopods (Rudwick, 1970).

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SURVEY ANNOUNCEMENTS

WATER WELL COMPUTER PRINTOUTS—A COUNTY ANALYSIS

In a previous article in "Pennsylvania Geology" (v 14/5, p. 6-7), we discussed the current status of our water well computer file. In addition to the information in that article, we have compiled the following table which gives the total number of printout sheets, the approximate number of wells contained on the printout, and the total cost of the printout per county:

	Approx. No. of Wells	Number of Printout Sheets	Total Cost In Dollars
Adams	44	297	11
Allegheny	52	351	13
Armstrong	60	405	15
Beaver	136	918	34
Bedford	224	1512	56
Berks	316	2133	79
Blair	84	567	21
Bradford	116	783	29
Bucks	488	3294	122
Butler	180	1215	45
Cambria	132	891	33
Cameron	20	135	5
Carbon	168	1134	42
Centre	40	270	10
Chester	584	3942	146
Clarion	12	81	3
Clearfield	12	81	3
Clinton	32	216	8
Columbia	44	297	11
Crawford	100	675	25
Cumberland	188	1269	47
Dauphin	384	2592	96
Delaware	24	162	6
Elk	16	108	4
Erie	196	1323	49
Fayette	36	243	9
Forest	20	135	5
Franklin	96	648	24
Fulton	24	162	6
Greene	16	108	4
Huntingdon	68	459	17
Indiana	104	702	26
Jefferson	68	459	17
Juniata	36	243	9
Lackawanna	84	567	21
Lancaster	532	3591	133
Lawrence	76	513	19
Lebanon	376	2538	94
Lehigh	272	1836	68
Luzerne	44	297	11
Lycoming	88	594	22
McKean	48	324	12
Mercer	68	459	17
Mifflin	84	567	21
Monroe	352	2376	88
Montgomery	380	2565	95
Montour	32	216	8
Northampton	248	1674	62
Northumberland	64	432	16
Perry	68	459	17
Philadelphia	—	—	—
Pike	124	837	31
Potter	48	324	12
Schuylkill	100	675	25
Snyder	40	270	10
Somerset	88	594	22
Sullivan	40	270	10
Susquehanna	44	297	11
Tioga	108	729	27
Union	100	675	25
Venango	164	1107	41
Warren	28	189	7
Washington	116	783	29
Wayne	88	594	22
Westmoreland	128	864	32
Wyoming	36	243	9
York	244	1647	61

Requests can be made for partial county printouts on a township by township basis. The cost would then be figured at: 10 or fewer sheets-no charge; more than 10 sheets-25 cents per sheet including the first 10 sheets. In addition, a $7.50 per hour charge would be added to the 25 cents per page charge for staff time spent searching and assembling data.

The printouts are available from the Pennsylvania Geological Survey - WWI, P. O. Box 2357, Harrisburg, PA 17120; telephone: 717-787-5828.

REPORT ISSUED ON OIL AND GAS DEVELOPMENTS

Pennsylvania's oil production, considered by many to be a thing of the past, reached a total of 4,282,354 barrels in 1982 with a value in excess of $120 million before refining. Comprehensive information on oil and gas production, exploration, and drilling activities in the Commonwealth is contained in the newly released **Oil and Gas Developments in Pennsylvania in 1982,** issued by DER's Bureau of Topographic and Geologic Survey.

The 120-page annual report, compiled by Dr. John Harper, Chief of the Survey's Oil and Gas Geology Division, is replete with tables, maps, and descriptions of the oil and gas developments on a county by county basis.

Natural gas production for the year totalled over 121 billion cubic feet with a total value of over $300 million dollars. Complementing the gas production was 6 percent increase in natural gas reserves, a tribute to the aggressive exploration and development program being conducted by the industry.

During the year, 4,224 new wells were drilled, a 19 percent increase over the previous year. The most active counties for oil drilling were Venango, Forest, Warren, and McKean; the most active counties for gas drilling were Indiana, Erie, Crawford, Clearfield, Jefferson, and Westmoreland.

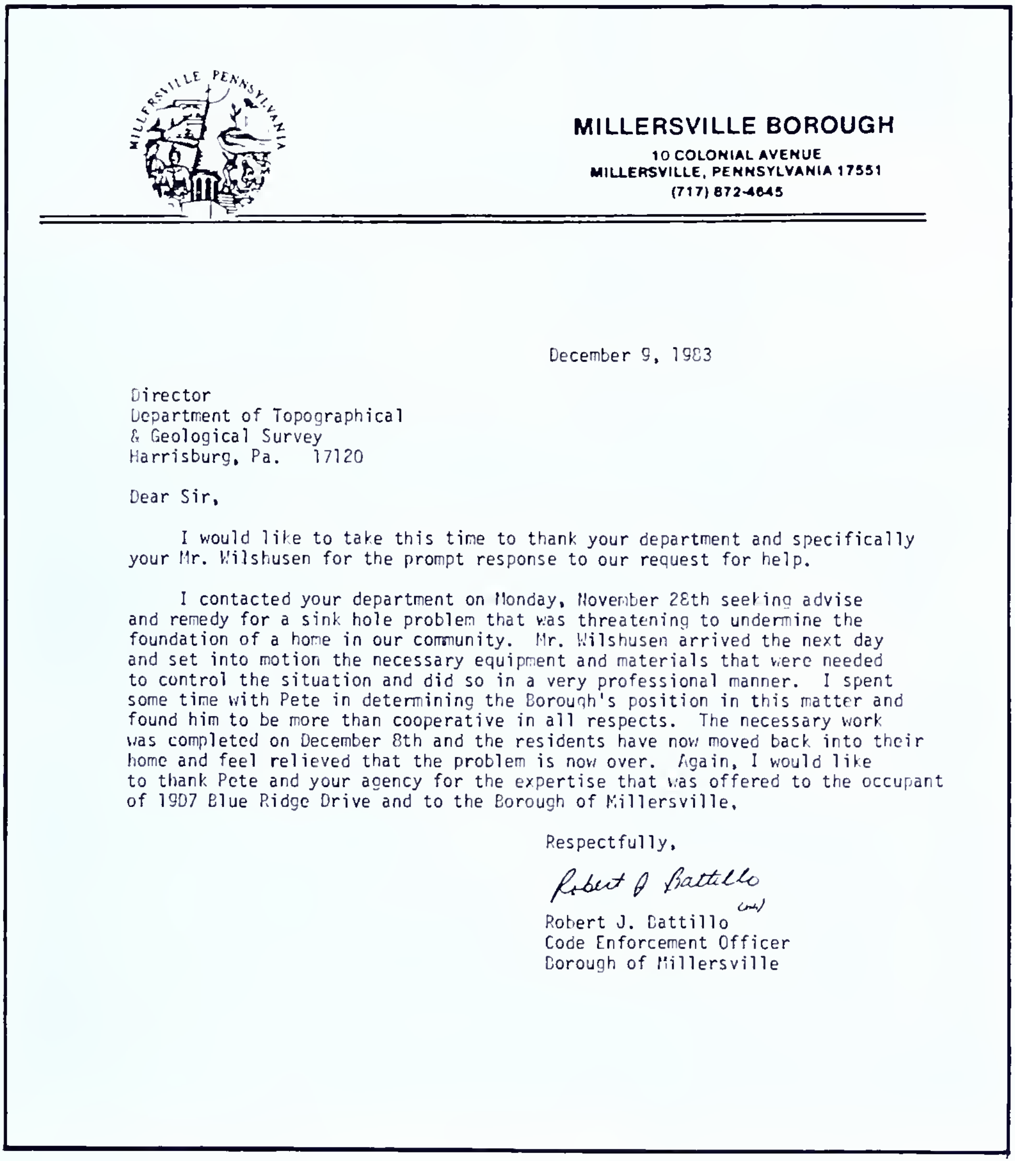
The new report also provides information on seismic exploration activities, secondary and tertiary oil recovery projects, and on oil and gas research projects in progress at the Survey.

Progress Report 196, **Oil and Gas Developments in Pennsylvania in 1982,** is available from the State Book Store, P.O. Box 1365, Harrisburg, PA 17105 for $1.90 (plus 12¢ tax for Pennsylvania residents). Check made payable to the Commonwealth of Pennsylvania must accompany the order.

A SERVICE RENDERED

Several hundred times a year we receive requests for geological advice and assistance. We are always pleased to respond, not only as part of our assigned mission, but also in a firm belief that geologists have an important contribution to make to our society.

Too often we don't hear how things worked out with the problems brought to our attention. In the case of this Lancaster County sinkhole problem, however, we have documentation of a happy ending to a serious situation. We are pleased to share with our readers the comments we have received.



MILLERSVILLE BOROUGH
10 COLONIAL AVENUE
MILLERSVILLE, PENNSYLVANIA 17551
(717) 872-4645

December 9, 1983

Director
Department of Topographical
& Geological Survey
Harrisburg, Pa. 17120

Dear Sir,

I would like to take this time to thank your department and specifically your Mr. Wilshusen for the prompt response to our request for help.

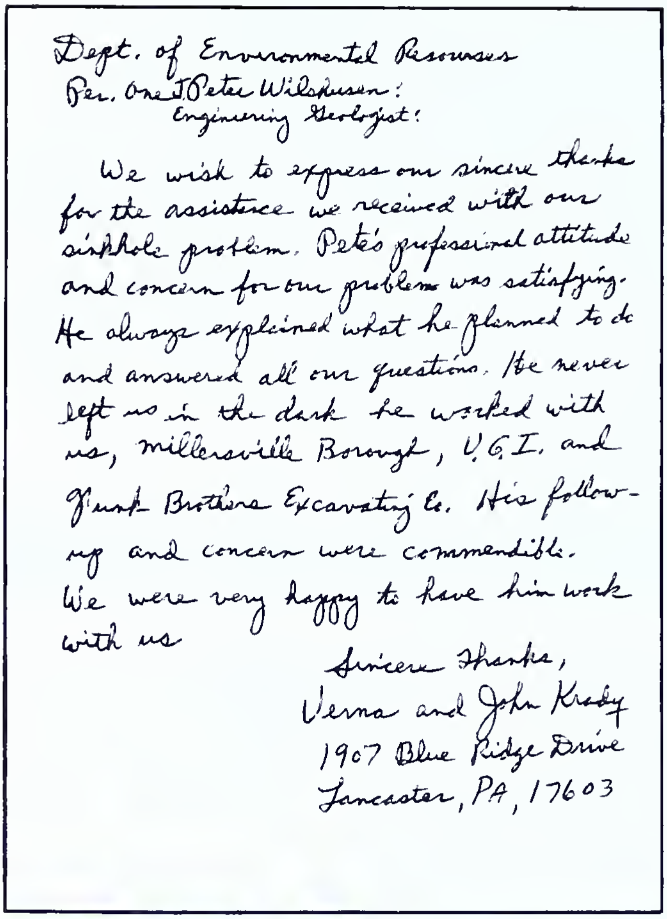
I contacted your department on Monday, November 28th seeking advise and remedy for a sink hole problem that was threatening to undermine the foundation of a home in our community. Mr. Wilshusen arrived the next day and set into motion the necessary equipment and materials that were needed to control the situation and did so in a very professional manner. I spent some time with Pete in determining the Borough's position in this matter and found him to be more than cooperative in all respects. The necessary work was completed on December 8th and the residents have now moved back into their home and feel relieved that the problem is now over. Again, I would like to thank Pete and your agency for the expertise that was offered to the occupant of 1907 Blue Ridge Drive and to the Borough of Millersville.

Respectfully,

Robert J Battillo

Robert J. Battillo
Code Enforcement Officer
Borough of Millersville

(continued on page 16)

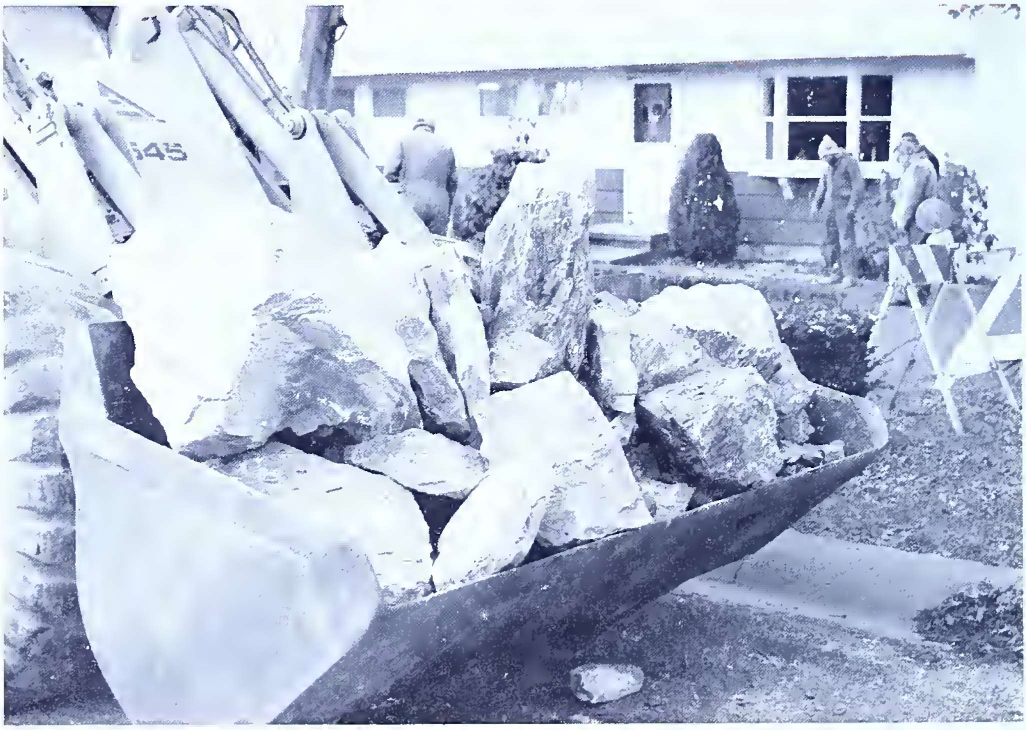


Dept. of Environmental Resources
Per. One J. Peter Wilshusen:
Engineering Geologist:

We wish to express our sincere thanks for the assistance we received with our sinkhole problem. Pete's professional attitude and concern for our problem was satisfying. He always explained what he planned to do and answered all our questions. He never left us in the dark he worked with us, Millersville Borough, U.G.I. and Funk Brothers Excavating Co. His follow-up and concern were commendible. We were very happy to have him work with us

Sincere Thanks,
Verna and John Krady
1907 Blue Ridge Drive
Lancaster, PA, 17603

Load of coarse stone to be placed with concrete into large sinkhole visible in front of house.



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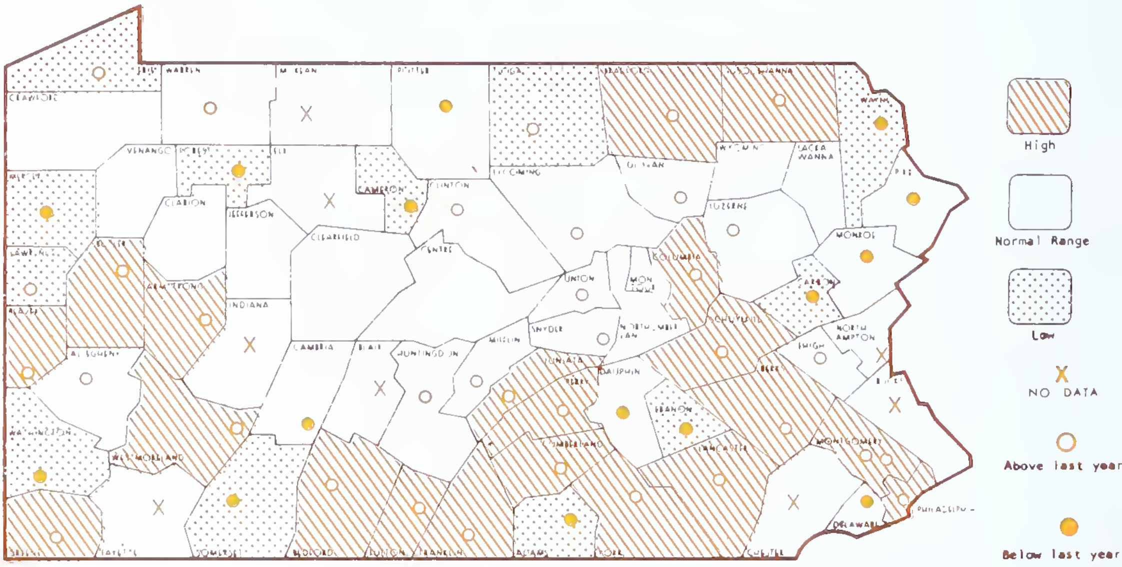

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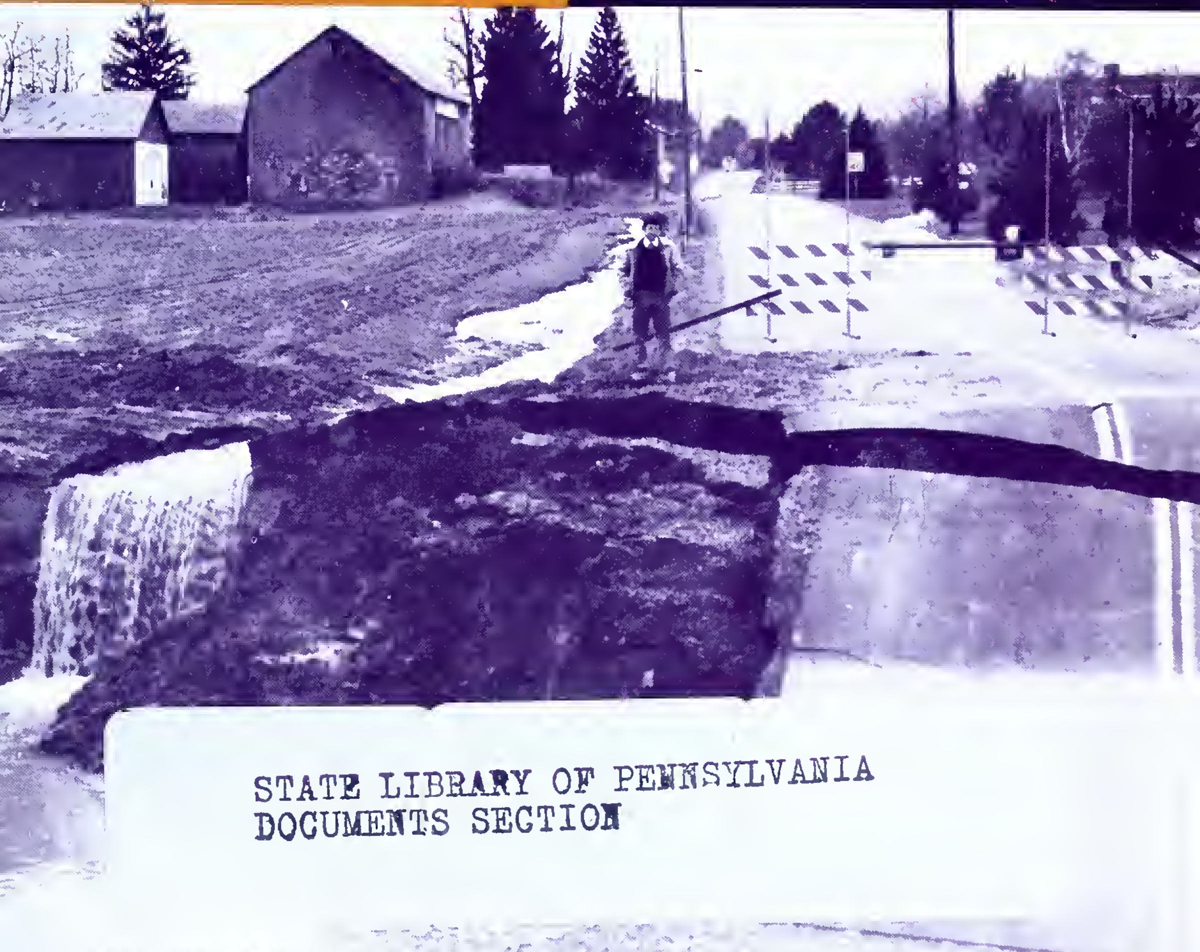

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ON THE COVER: Westward-looking view across new sinkhole astride Vera Cruz Road, Upper Saucon Township, Lehigh County (See article).

PENNSYLVANIA GEOLOGY is published bimonthy by the Topographic and Geologic Survey, Pennsylvania Dept. of Environmental Resources, Harrisburg, Pennsylvania, 17120.

Editor, Arthur A. Socolow; Associate Editor, Donald M. Hoskins.

Articles may be reprinted from this magazine if credit is given to the Topographic and Geologic Survey.

VOL. 15, No. 3 **JUNE, 1984**

FROM THE DESK
OF THE
STATE GEOLOGIST

THE EARTH MOVES IN PENNSYLVANIA

Most people think geology is a dead subject. Rocks, after all, are inanimate and we measure their ages in thousands and tens of millions of years. But every so often we are reminded that geology is alive, and not just the story of Earth's past history. So it was that this past April 22th we were "visited" here in Lancaster County by an earthquake; the manifestation of movement beneath the earth's surface of rocks sliding against rocks. (See this issue for more detailed account.) Earthquakes in Pennsylvania are not really rare; they have been recorded many, many times in the history of our state, including several in recent years. Fortunately, they have been minor, causing little or no damage, with no known basis to assume that any more serious are likely to occur soon. The earthquakes, however, are a gentle reminder that the earth is not dead, that there are forces and stresses which continue to develop and periodically manifest themselves as evidence that changes on and in the earth are continuing.

Another geological process in action demonstrated itself several weeks ago when an impressive sinkhole developed across a road in Lehigh County (see cover and story). Unlike earthquake origins, sinkholes develop from a type of erosional process, where seeping water first dissolves some of the underlying limestone rocks, subsequently resulting in a collapse of the overlying rock and soil cover. But again, the ongoing sinkhole developments we have been witnessing are evidence that the Earth is not yet completed, that processes are at work resulting in changes. Often these processes are slow and subtle, but many do impact seriously upon man, such as the development of sinkholes, landslides, and floods. As geologists we not only record the events of long ago, but also try to monitor the ongoing processes so that we may better predict and plan for their impacts.

Arthur A. Socolow

LANCASTER'S EASTER EARTHQUAKE

by Charles K. Scharnberger
Millersville University

At 8:36 p.m. on Sunday, April 22, residents of southeastern Pennsylvania were shaken by a magnitude 4.1 earthquake centered in southern Lancaster County. This tremor was felt as far away as southeastern New York and northern Virginia. Four days earlier, at 11:55 p.m., an event with a magnitude of approximately 3 was felt over a much smaller area. This April 18 quake can now be regarded as a foreshock of the Easter Sunday earthquake.

Both events, but especially the larger one, generated a good deal of excitement in Lancaster and York Counties, inquiries from police and emergency planning agencies, and considerable interest on the part of the news media. Altough the maximum intensity was V on the Modified Mercalli scale (unstable objects overturned, walls creak, some china broken), fears of the effects of a larger quake in the future were common. There is no historical record of quakes with maximum intensity greater than VI in the lower Susquehanna Valley area, all considered minor. The largest known East Coast earthquake (Charleston, S.C., 1886) had a maximum intensity of X (many masonry structures destroyed, rails bent, ground cracks).

Detailed investigation of the April 22nd earthquake began almost immediately and is continuing. Both Penn State University and the Lamont-Doherty Geological Observatory of Columbia University sent teams with portable seismographs into the area to "chase" aftershocks. The first field instrument was set up about 5:00 a.m. Monday by John Armbruster of Lamont who had driven to Lancaster from New York during the night. By mid-afternoon Monday five seismographs were recording in an array surrounding the epicenter near Marticville. Later, two more instruments arrived from New York, including a state-of-the-art digital seismograph.

Ten aftershocks occurring over the next four days were recorded and seven of these were located with a high degree of precision. Four aftershocks, two strong enough to be felt over a considerable distance, had been recorded by Millersville's seismograph before the field array was in place. All located aftershocks were a little more than 4 km. deep and had epicenters along a 2 km. long line striking about N12 E located about 2 km. west of Marticville. Analysis of the first motions of the aftershocks, as well as the main shock, suggests a fault plane striking roughly N10 E and dipping about 60 to the east. The sense of motion is mostly reverse-slip, with a small right-lateral strike-slip component. The axis of maximum compression was nearly horizontal and oriented about N80 E. This analysis was carried out by Leonardo Seeber, Research Associate at Lamont-Doherty and is reported here with his permission.

A second line of research has been the determination of intensities. Intensity information from the Lancaster-York area has been accumulated by the author from newspaper questionnaires, personal conversations and reports from students from the Penn Manor and Solanco High Schools. Mr. Robert Wyble of Penn Manor and Mr. Lewis Bryson of Solanco were extremely helpful in this study. In fact, so much data has been collected that it will be some time before it is thoroughly analysed. This is especially true for Wednesday night's foreshock which has been put on the back burner, but which may provide some interesting comparisons with Sunday's event. A rough isoseismal map for the April 22 quake is shown in Figure 1. The elliptical shape of the zone of maximum intensity may be related to the orientation of the fault plane or to the effects of local geologic structure. The apparently larger area of in-

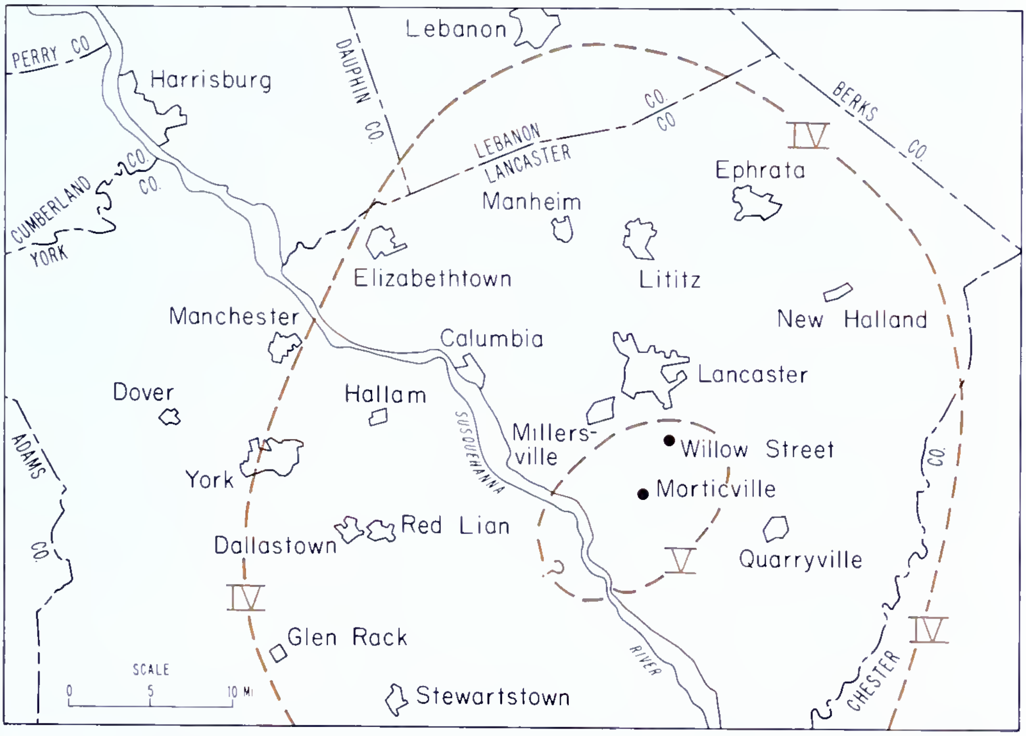

Figure 1. Isoseismal map for April 22, Lancaster County earthquake. Modified Mercalli scale of 1931.

tensity IV to the north and west may be attributed to the presence of carbonates in that region in contrast to schist to the south and east; or to the northwestward thrust of the fault motion; or it may be an artifact of the much larger number of reports received from areas to the north and west. This may be clarified by further study.

Dr. Shelton Alexander and Dr. Benjamin Howell of Penn State are investigating the intensities on a larger, regional scale. Their results, not available at this time, will have to be combined with the local intensity study to get a fuller picture.

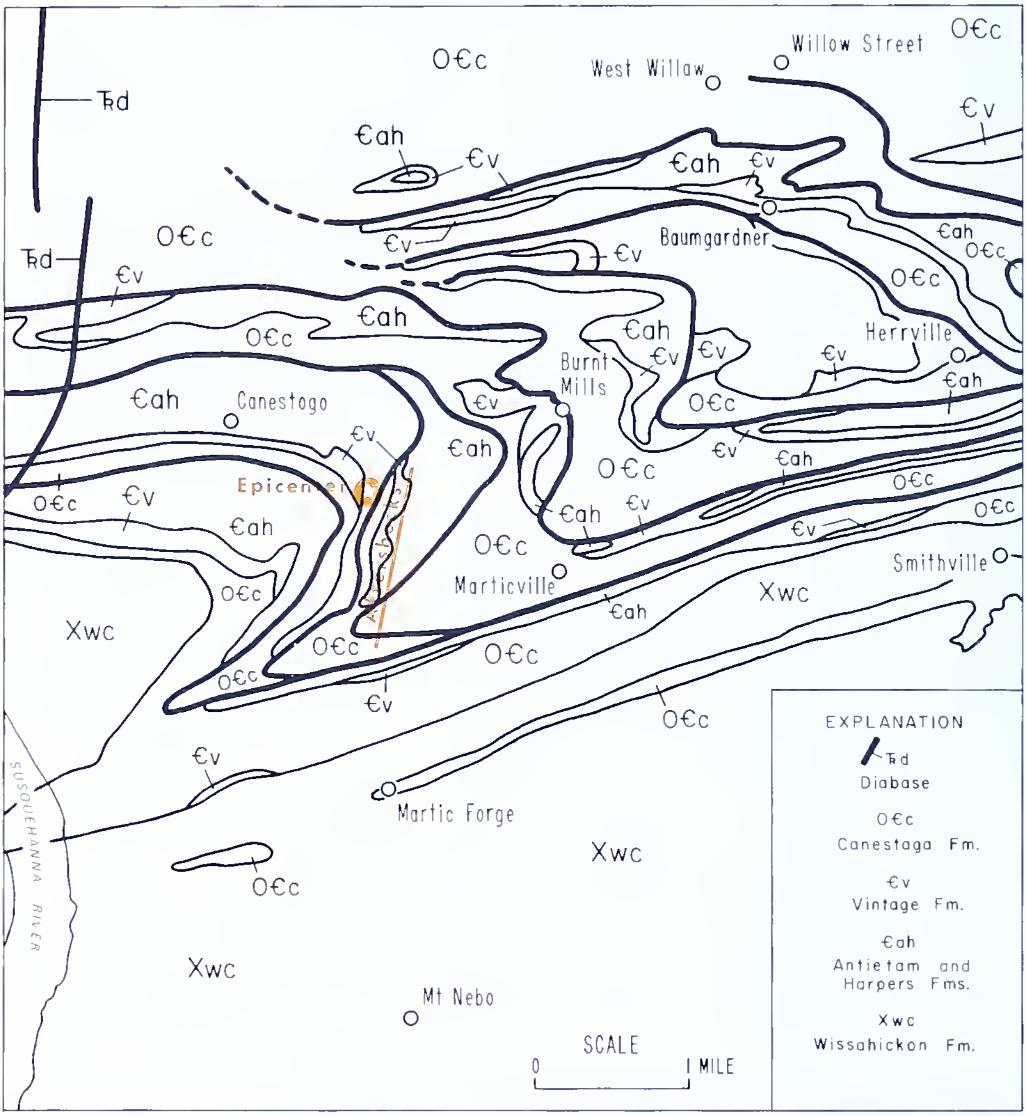

Figure 2. Approximate epicenter and line defined byepicenters of seven aftershocks; April 22, Lancaster Co. earthquake.(Data from L. Seeber, Lamont-Doherty Geological Observatory.)Geology from Pa. Geological Survey, Map 61.

The problem of geologic interpretation of this event is quite interesting. Figure 2 is the geologic map of the Conestoga Quadrangle with the approximate epicenter of the main shock and the aftershocks located. The main shock seems to have had a somewhat shallower hypocenter than the aftershocks, hence its position to the northwest of the line of aftershock epicenters.

The most obvious geologic features of this area are the curving ridges of Antietam-Harpers-Vintage Formations that have been interpreted as folded thrust slices (Wise, 1970). Just to the south is the enigmatic "Martic Line" which may or may not be an early Paleozoic overthrust (see a recent review by Arnold, 1983, for a summary of this controversy). My first thought was that earthquakes in this part of Lancaster County, both this event and the one in July 1978 (Scharnberger, 1978), are probably related to the thrust slices or perhaps to the fact that the Martic Line makes two northward jogs in this area. Unfortunately, the tentative nature of this hypothesis was usually not, reflected in press reports which attributed the earthquake to the "Martic Fault" and sometimes implied that southeast Pennsylvania sits astride a zone of major earthquake potential. However, in view of the first-motion and aftershock studies, it seems more likely that the earthquakes are related to Triassic age structures in the area. A diabase dike about 4 km. to the west of the epicentral area has a strike (though probably not a dip) similar to the inferred fault plane. It is also interesting to note that magnetite and sulfide mineralization is present in the vicinity of the epicenter.

Six earthquakes of magnitude 3 or greater have occurred in or very near Lancaster County in the past 20 years (1964, 1972, 1978 (2) and 1984 (2)). Prior to 1964, we have to go back to 1889 to find another local event. Does this mean that seismic activity is on the increase in the lower Susquehanna Valley? Is a "seismic gap" being filled in? Are these quakes precursors of a larger event to come or have the quakes relieved the stress for good? There are questions that make seismology an exciting, if somewhat uncertain, science. It may be that Lancaster's Easter earthquake will help provide important clues in this on-going investigation.

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1984 Field Conference of Pennsylvania Geologists

The 49th Annual Field Conference of Pennsylvania Geologists, Inc. will be convened Thursday, October 4, 1984, in Wyomissing, PA, at the Reading Motor Inn. The focus of the 1984 trip is a detailed description of the stratigraphy and sedimentology of the "Ordovician" rocks of the Hamburg Klippe now known to range from Cambrian to Ordovician in age. The trip will include several stops within the Klippe rocks near Hamburg, PA, and will include a stop on the top of the Spitzenberg where can be seen the famous outcrops of limestone clasts in reddish matrix. Upper Silurian-Lower Devonian rocks will also be seen in the Andreas quarry which also demonstrates extensive structural complexities.

The Conference will begin Thursday evening at the Reading Motor Inn with a slide presentation by the field trip leaders, Gary Lash of Fredonia State University College and Peter Lyttle and Jack Epstein of the U. S. Geological Survey. A reception follows the orientation. Friday and Saturday will be devoted to field trips and will feature a luncheon of Pennsylvania Dutch sausage and cheeses on top of Spitzenberg and a country-style hot lunch on Saturday.

The stop at Spitzenberg involves a considerable climb. Four-wheel drive vehicles will be provided for those participants who need help to get to the hill top.

Due to space limitations at some stops for buses and people, participation on the trip is absolutely limited to the first 170 reservations received. If you desire to attend and plan to be away during August when the final announcement and reservation form is mailed, you may reserve space now by letter (Field Conference of Pa. Geologists, c/o Pa. Geological Survey, P.O. Box 2357, Harrisburg, PA 17120) guaranteeing payment of the registration fee.

The 1984 Field Conference is headquartered centrally to the many shopping outlets for which Reading is well known. Perhaps your spouse will desire to come to the Conference to do shopping while you are conferencing! Think of all the money she can save.

Our Best Sellers

With over 400 of the Pennsylvania Geological Survey's reports and maps available to the public through the State Book Store, it's always of interest to see which of those publications are currently heading the list of best sellers.

In 1983 the top ten reports sold amongst our geological publications were as follows:

1. EG1 Engineering Characteristics of the Rocks of Pennsylvania
2. PR 195 Oil and Gas Developments in Pennsylvania in 1981
3. G 33 Mineral Collecting in Pennsylvania
4. G 72 Fossil Plants from the Anthracite Coal Fields of Eastern Pennsylvania
5. M 25 Oil and Gas Geology of the Oil City Quadrangle
6. EG7 Outstanding Scenic Geological Features of Pennsylvania
7. M 81 The Oriskany Sandstone in the Subsurface of Pennsylvania
8. M 52 Oil and Gas Geology of the Warren Quadrangle
9. G 59 Geology of the Pittsburgh Area
10. M 61 A Summary of Major Geophysical Logging Methods

Of our published geologic maps the leading sellers were:

1. Map 3 Oil and Gas Fields of Pennsylvania
2. Map 1 Geologic Map of Pennsylvania
3. Map 61 Preliminary Geologic Maps of Pennsylvania

It is noteworthy that in terms of major categories these best sellers deal with the subject areas of (1) oil and gas exploration, (2) geologic recreational activities, and (3) basic geology and engineering characteristics of Pennsylvania's rocks.

Anyone interested in a complete listing of our geologic reports and maps should send a request to: Bureau of Topographic and Geologic Survey, P.O. Box 2357, Harrisburg, PA 17120.

Errata

In the April 1984 issue of Pennsylvania Geology, the table showing the county analysis of the water well computer printouts contained a printing error in the headings. The first numerical column should carry the title "Number of Printout Sheets" and the second numerical column should carry the title "Approx. No. of Wells." These two column headings were reversed in error on the table.

On page 7 of the April issue it should read that "1 kilometer on the ground" equals "about 0.6 miles." *Not* 1.6 miles.

Dating of the Formation of the Slippery Rock Gorge

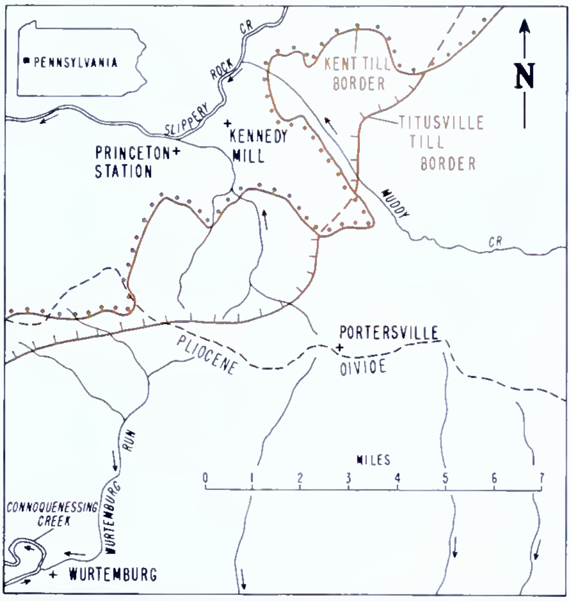
by Gary M. Fleeger
Denver Colorado

Prior to glaciation in western Pennsylvania, drainage was north into the St. Lawrence River basin. During glaciation ice advanced from northwest to southeast and blocked these streams, causing the development of extensive lakes in front of the ice. These lakes were forced to drain south through low points (cols) in the drainage divides. In some places lake drainage cut completely through a divide and a permanent stream reversal resulted. Slippery Rock Creek is an example of one of these drainage changes which has been studied carefully during the past 50 years (Cooley, 1935; Delliquadri, 1951; Preston, 1948, 1950, 1977).

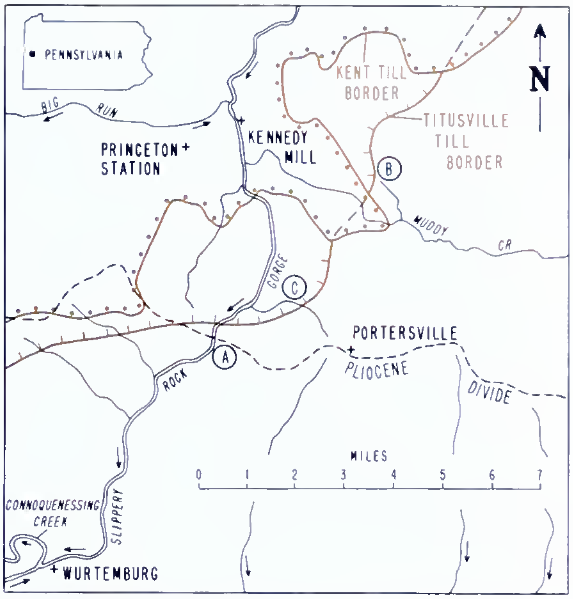
During glaciation a west-flowing Slippery Rock Creek (Fig. 1A) was dammed and a pro-glacial lake system was formed in the Slippery Rock watershed in northern Butler, southern Mercer, and eastern Lawrence Counties (Fig. 2). Lake Arthur in Moraine State Park, Butler County is a partial reconstruction of glacial Lake Watts, one of the lakes of this system. The drainage of the lakes over the divides resulted in the formation of several deep, narrow valleys, the most prominent being the Slippery Rock gorge at McConnells Mill State Park in Lawrence County. Slippery Rock gorge is about 12 miles long (Fig. 1B) and has a maximum depth of 400 feet at Cleeland Rock (Fig. 1B, Site A). Dating the time of cutting of the gorge has been a major problem. All previous studies have assumed it to have been during the last glaciation, 23,000 years ago (Kent glaciation). The problem may be resolved by noting several features of erosion and deposition related to drainage reversal.

The present Muddy Creek valley was cut by the draining of glacial Lake Watts as the ice retreated (Preston, 1977). The Slippery Rock gorge was formed before the present Muddy Creek valley because the water from that valley drained to the south through the gorge.

Two features demonstrate that the present Muddy Creek valley, and therefore the Slippery Rock gorge existed prior to the Kent glaciation and must have been formed during an earlier glaciation. First, the distribution of Kent Till (Shepps and others, 1959), indicates that a lobe of Kent ice extended southeast into the present



1A. Drainage before the drainage diversion and formation of the Slippery Rock gorge. (Modified from Preston, 1977).



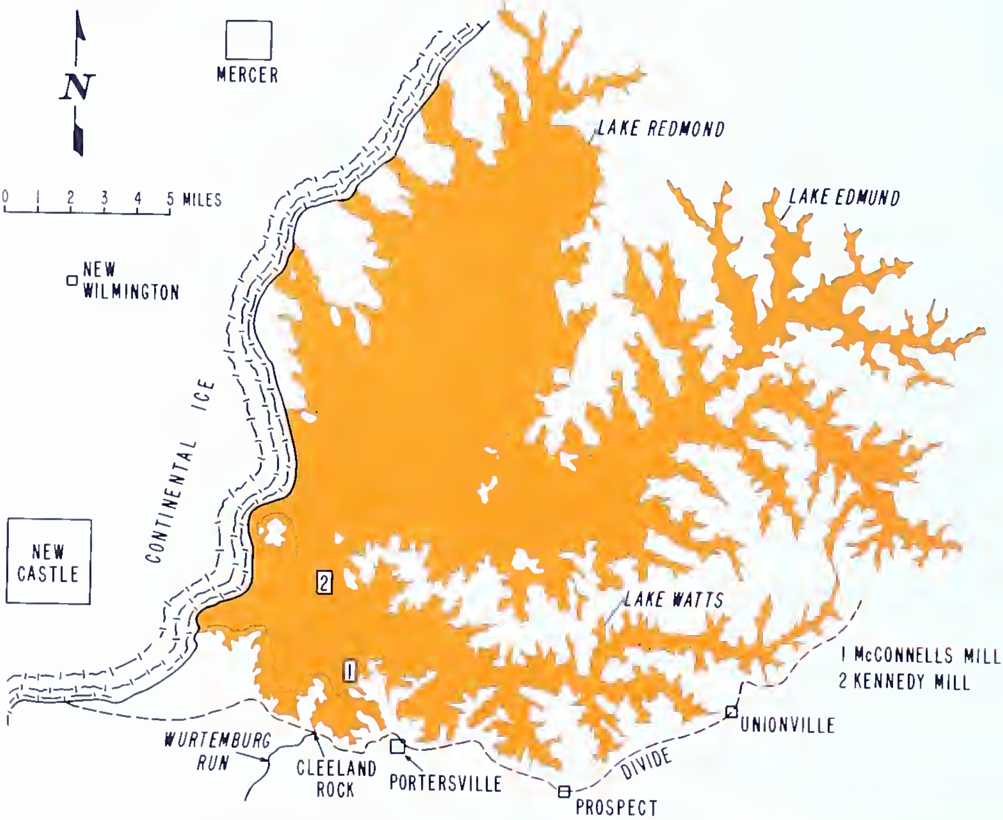
1B. Present drainage.

Muddy Creek valley from Kennedy Mill (Fig. 1B). Thus the valley must have existed prior to Kent glaciation. Secondly, a bed of varved clays exists in the present Muddy Creek Valley (Preston, 1977) which could have deposited during a glaciation only after the valley had been formed. Construction along the north shore of modern Lake Arthur (former glacial Lake Watts) exposed two sets of varves (Jesse Craft, pers. comm.), also suggesting two periods of lake formation.

In addition, before the formation of its present valley, Muddy Creek followed a course farther to the north (Fig. 1A) (Preston, 1977). The lower part of this valley is a tributary to modern Muddy Creek. This valley can be followed to its upstream termination at the Titusville Till border (Fig. 1B-Site B). This suggests that the Titusville advance permanently filled the original Muddy Creek valley.

The erosion of the divide that resulted in the formation of the Slippery Rock gorge was caused by the overflow from Lake Watts (Preston, 1977). The presence of a thin layer of Titusville Till overlying Lake Watts deltaic sediments (Fig. 1B-Site C) is evidence that Lake Watts existed as an ice marginal lake during the Titusville advance.

The accumulated evidence suggests the following sequence of events: During the advance of Titusville ice, 40,000 years before present (White and others, 1969) the west-flowing drainage of Slippery Rock Creek was disrupted and a lake system developed in Butler, Mercer, and Lawrence Counties. Drainage through the col at Cleeland Rock eroded the divide and as the ice front retreated drainage was maintained through the new gorge and Slippery Rock Creek was diverted to the south. At its maximum advance, the ice blocked the Cleeland Rock col (temporarily opening another), covered deltaic deposits in the ice marginal lake, and deposited sediments that blocked the former courses of Slippery Rock and Muddy Creeks. During ice recession, lake drainage around the margin of the ice formed the new course of Muddy Creek. During the maximum extent of the later Kent ice advance, 23,000 years before present (White and others, 1969), a lobe of ice extended down the new Muddy Creek valley and parts of the earlier lake system reformed, depositing varves in the present Muddy Creek valley and the second set in Lake Watts. The ice receded, allowing the lakes to drain through the Slippery Rock gorge, further deepening it. No permanant drainage changes resulted from the Kent glaciation.



2. Maximum extent of pro-glacial lakes during Titusville advance. (Modified from Preston, 1977).

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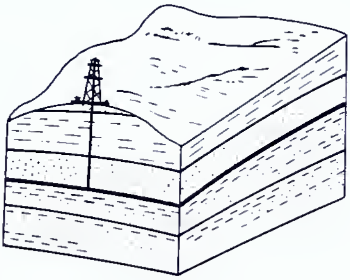


Ownership Of Coalbed Gas

In a decision of considerable interest and importance to many Pennsylvanians, the Pennsylvania Supreme Court ruled this past December that gas extracted or emanating from a bed of coal is the property of whoever owns or leases the coal itself. That ruling overturned an earlier decision by the lower Court of Common Pleas for Greene County which had found (in the case of U.S. Steel v. Hoge, et al) that the gas in the coal belongs to the owner of the gas rights of any property.

This decision will be of increasing importance in coming years as new technology results in increasing attempts to extract and market methane from various Appalachian coal beds.

The losing parties in this decision by the State Supreme Court have not yet announced whether they plan to appeal the latest ruling of the U.S. Supreme Court.

ANTHRACITE DATA ON OPEN FILE

A map showing the distribution of anthracite coal seems in the Conyngham 7½-minute quadrangle has been placed on open file at the Harrisburg office of the Pennsylvania Geological Survey at 914 Executive House, Second and Chestnut Streets. This quadrangle covers part of the Eastern Middle Anthracite Field just west of Hazleton. The 1:12,000-scale (1 in. = 1000 ft.) map is available for inspection or tracing, but may not be removed from the Survey offices. The map shows the coal bed outcrop lines, fold axes, faults, strip mined areas, and mine slopes, shafts, and tunnels. The coal shown on the map range from the Buck Mountain upward to the Orchard, including the Mammoth seam.

Three tables are included in the open file. One shows the average thickness and range of thickness of the coal seams. A second table lists the coal resources in millions of short tons by seam. The third table lists total coal resources by thickness category and depth of overburden. The map and coal resource tables were prepared by David B. MacLachlan of the Geologic Mapping Division.

Plant Fossil Listing Open Filed

Pennsylvania's museums contain many fine fossil plant specimens from the Anthracite fields of northeastern Pennsylvania. But except for some listings from the James and Unger Collections by William C. Darrah (1969, *A Critical Review of the Upper Pennsylvania Floras of Eastern United States,* etc.), the bulk of the contents of these collections has remained unpublished. In 1975, Mr. William F. Klose, II began the task of preparing summary lists of these collections from specimen labels and museum catalogs. They constitute a significant increase in our knowledge of the fossil associations from specific locations and horizons in the "coal measures" of northeastern Pennsylvania. We hope this will spur a restudy of the entire flora of the Pennsylvania Anthracite fields.

The Pennsylvania Geological Survey is pleased to release the results of Mr. Klose's endeavors as an open-file report entitled *Summary Lists of Fossils from the Anthracite Fields and Nearby Areas of Northeastern Pennsylvania.*

This open-file report may be examined in the office of the Pennsylvania Geological Survey on the 9th floor of the Executive House, 2nd and Chestnut Streets, Harrisburg, PA 17101. The abstract of the 373-page report is published below to provide a formal citation source for those who might wish to cite Mr. Klose's work in a bibliography or list of references.

Summary Lists of Fossils From The Anthracite Fields and Nearby Areas of Northeastern Pennsylvania

by William F. Klose, II
Noxen, PA

ABSTRACT

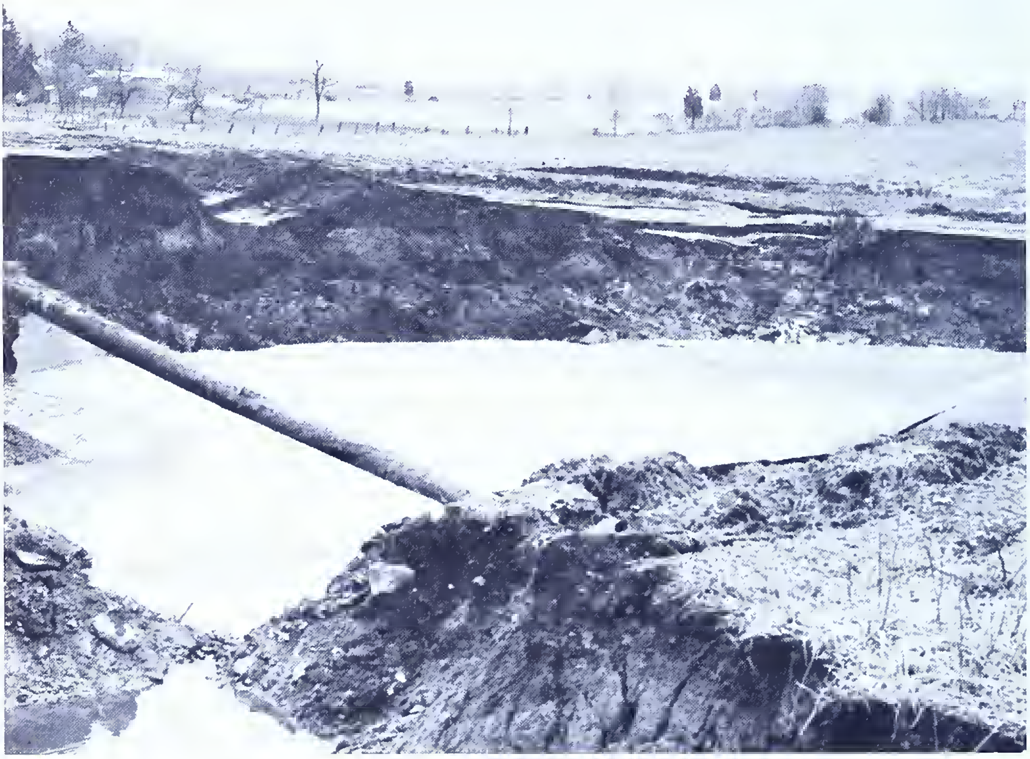
Fossils from the Anthracite fields and nearby areas of northeastern Pennsylvania in the James, Oleksyshyn, and Klose Collections at the William Penn Memorial Museum, Harrisburg, Pennsylvania and the Unger Collection in the Reading Public Museum and Art Gallery, Reading, Pennsylvania are listed. The specimens are representative of 233 different localities. Most are Pennsylvanian plant fossils, but a few Middle Devonian to Mississippi plant fossils and Pennsylvania invertebrate fossils are included. The lists are based on specimen labels and collection catalogs. Paleontologic nomenclature has been updated to conform to modern usage.

The location lists are combined into horizon lists with location numbers and are compared to the early locality lists prepared by Lesquereux (1884) and White (1900). Ninety three species are reported from the Olyphant No. 1 anthracite horizon, 206 species from the Checker/Holmes anthracite horizon, 308 species from the Baltimore/Mammouth anthracite horizon, 91 species from the Marcy/Big Vein anthracite horizon, 149 species from the Ross/Clarke anthracite horizon, and 265 species from the Buck Mountain (No. 5)/Red Ash/Dunmore anthracite horizon. The flora of the Bernice semi-anthracite horizon from the Bernice field, Sullivan County, Pennsylvania, is established at 95 species; it is assigned to the Upper Alleghenian (Westphalian D).

Nine species of previously unreported Pennsylvanian invertebrates are listed. These include 4 insects, 2 arachnids, 1 trilobitomorph, 1 xiphosurid, and 1 annelid.

New Lehigh County Sinkhole

The development of a spectacular 80-foot diameter sinkhole across the Vera Cruz Road in Upper Saucon Township, Lehigh County this past December is dramatic evidence that the long record of sinkhole development in that area, known as Saucon Valley, is a continuing one. Underlain by a limestone formation that is particularly prone to being gradually dissolved by downward-seeping water, sinkholes were being found in this valley long before man set foot there. But as man's settlement of the valley took place, first to utilize the fertile farmland, then to extract the valuable mineral resource of the valley, and more recently for home development in this lovely setting away from urban congestion, all those activities caused some disruption in the groundwater movement which have tended to accelerate the creation of sinkholes.



View across 80-feet diameter sinkhole which cut Vera Cruz Road. Pole in foreground is remnant of an earlier subsidence repair project. Field in background contains many shallow depressions suggesting possible sinkholes to come.

While the new sinkhole astride the Vera Cruz Road was undoubtedly a long time in its formation, there is some indication that the final collapse was triggered by a disruption of the drainage pattern. Prior sinkhole development has been recognized at and near this site and there are subtle indications that new sinkholes are imminent nearby.

Evaluations and studies are being conducted on how best to deal with these road and travel disruptions which this new sinkhole has created. Certainly this is a classic demonstration of costly damage and inconveniences which sinkholes can create. While they represent a natural process which generally cannot be forestalled, an awareness of sinkhole-prone areas, coupled with appropriate land use planning and engineering, could avoid their accelerated development and minimize the hazards, cost and inconvenience of sinkhole occurrences.

Humor (?) In Geology

(Courtesy of Bob Bates via Charles Shultz)

If you get stoned every Friday, do you eventually become a geologist?

If you are inclined to do something bad, are you synclined?

Show me a fellow who loves stream deposits and I'll show you an alluvial fan.

Predicting earthquakes can be a shaky business.

Products of radioactive disintegration are called daughter elements. Why not son elements? Men's lib, unite!

I could have been a volcanologist, but I blew it.

I could have been an igneous petrologist, but I took it all for granite.

I could have been a glaciologist, but my geology courses snowed me.

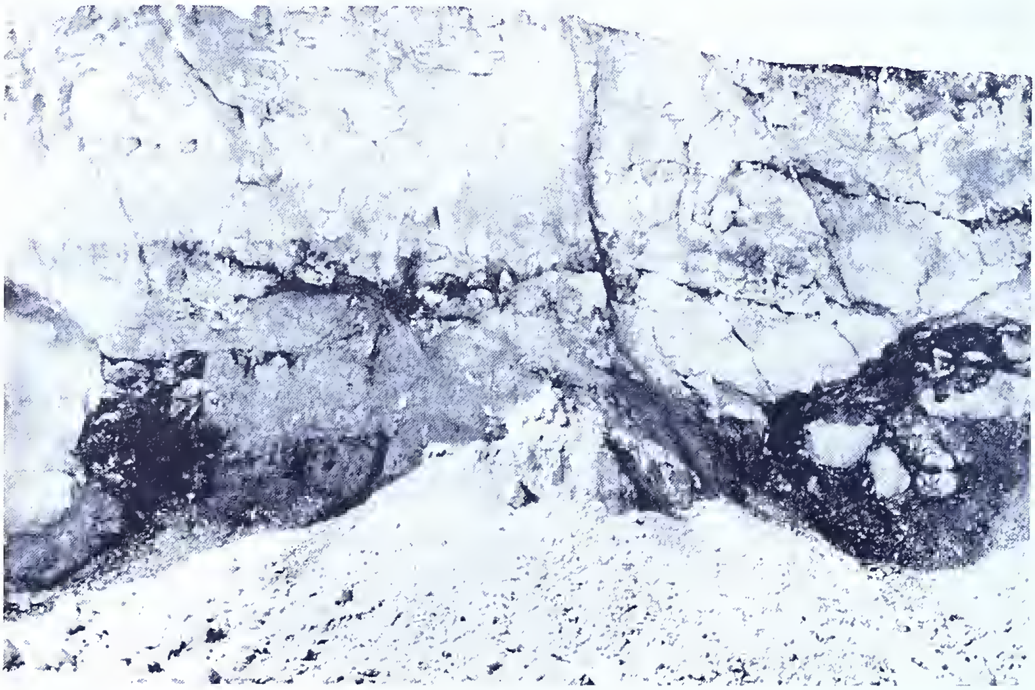
I could have been a mining engineer, but I just didn't dig it.

I could have been a successful photogeologist, but nothing developed.

I could have been a seismologist, but I was too shook after my last geology exam.

Harrisburg Area Geological Society Field Trip

Dark areas on both sides of photo represent probable Triassic age infiltration features (cave fillings?) observed in Cambrian age Ledger, dolomite exposed in J. E. Baker quarry, York County. These were viewed in April by some 30 geologists during 3rd Annual Field Trip of the Harrisburg Area Geological Society, led by Robert Ganis, Consulting Geologist, and David Hopkins of the J. E. Baker Company. Copies of the field trip guidebook to the four quarries and selected Paleozoic outcrops may be purchased from Bob Ganis, P.O. Box 6128, Harrisburg, Pa. 17112 at $6.00 each.



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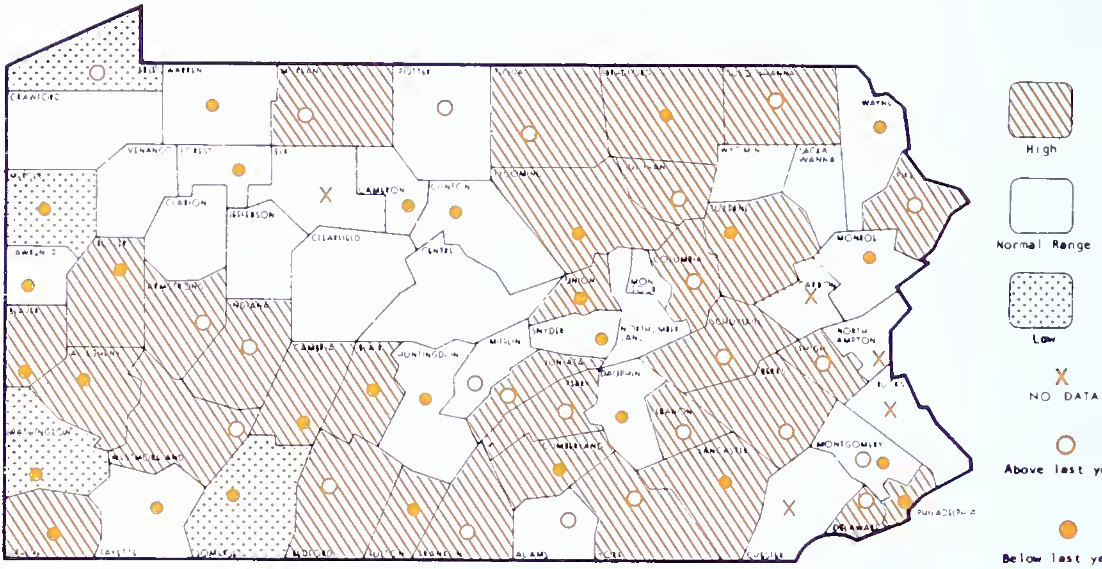

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ON THE COVER: Alan R. Geyer, retiring Chief of the Environmental Geology Division of the Pennsylvania Geological Survey, typically responding to a visitor's geologic question. Photo courtesy of Geary Sarno.

PENNSYLVANIA GEOLOGY is published bimonthy by the Topographic and Geologic Survey, Pennsylvania Dept. of Environmental Resources, Harrisburg, Pennsylvania, 17120.

Editor, Arthur A. Socolow; Associate Editor, Donald M. Hoskins.

Articles may be reprinted from this magazine if credit is given to the Topographic and Geologic Survey.

VOL. 15, NO. 4 **AUGUST, 1984**

FROM THE DESK
OF THE
STATE GEOLOGIST

A NICE GUY WHO IS FINISHING FIRST

A shining example of a person who belies Leo Durocher's classic pronouncement that "Nice guys finish last" is Alan Geyer, who has chosen to retire as Chief of our Environmental Geology Division after a span of service that extends back to 1951. Al's list of activities, accomplishments, and publications is long and significant. But I want to focus here on Al, the person. Here is a true gentlemen; unassuming, overwhelmingly considerate of others, kind, and gentle. And on top of those qualities there has also been a dedication to serve the citizens of the Commonwealth and a professional competency that will long serve as a model here at the Pennsylvania Geological Survey.

Al Geyer has over the years demonstrated an outstanding ability to unravel and describe highly complex geologic structures, as is exhibited in many of his published reports identified in the accompanying article. But Al has also shown an ability to understand and apply the relationship of geology to man, so that he has been extremely effective and ready to respond to the geologic problems and needs which so many of our citizens have placed before him. Furthermore, Al Geyer has been in the forefront, both on the state and national level, in recognizing the importance of developing geological education for all levels of the school curriculum.

For his countless professional contributions and assistance, the Pennsylvania Geological Survey and the citizens of Pennsylvania owe a great debt of gratitude to Al Geyer. For his warm comradeship and support, we of the Survey, as well as his legion of friends throughout the country, extend our deep appreciation. We join together in extending to Al our heartfelt wishes for long years of good health and happy retirement.

Arthur A. Socolow

Alan R. Geyer Retires

Alan R. Geyer, longtime Chief of the Environmental Geology Division of the Pennsylvania Geological Survey, announced his retirement effective September 19, 1984. Al Geyer, a native of Lancaster, Pennsylvania, did his undergraduate studies in geology at Franklin and Marshall College and his graduate studies at the University of Michigan. He first started work with the Pennsylvania Geological Survey on a part-time basis in 1951, then full time in 1953. After two years of military duty, Al Geyer returned to the Pennsylvania Survey in October of 1955 and was appointed Assistant State Geologist in 1957. In 1961 he served for several months as Acting State Geologist and in 1967, at his request, he was appointed Chief of the newly created Environmental Geology Division.

Under Al Geyer's direction the Environmental Geology Division developed many innovations, including a computerized water well data system, a landslide and sinkhole response program, a series of geologic park guides, and numerous field and laboratory guides for Pennsylvania's Earth Science education programs. Geyer's geologic Atlases of the Lebanon and the Womelsdorf Quadrangles are recognized for their scientific contributions and unique format, making them meaningful to both scientists and layman. His report on the "Engineering Characteristics of the Rocks of Pennsylvania" was a nationally innovative and functional presentation of the state's rock formations and his massive volume on "Outstanding Scenic Geologic Features of Pennsylvania" has become a best-seller by all standards. Tens of thousands of young and old Pennsylvanians have benefited from Geyer's input in "Common Rocks and Minerals of Pennsylvania" and the best-selling "Mineral Collecting in Pennsylvania". Geyer has been an active participant and officer of the National Association of Geology Teachers, as well as numerous Boy Scout, conservation, and Science Fair activities.

Space does not permit complete enumeration of all of Geyer's publications, technical services, lectures, committees, and counselling over the years. All this has been done with grace, enthusiasm, and highest standards. Alan Geyer has made an outstanding contribution to the geologic community and to the public at large.

GEOLOGICAL RESEARCH IN PENNSYLVANIA 1984

INTRODUCTION

This publication is the twenty seventh annual report on Geological Research and Publications in Pennsylvania. It is an attempt to list all current geologic research in Pennsylvania and includes persons and projects other than those of the Pennsylvania Geological Survey. Because of the large number of projects reported to us, we exercise editorial license to reduce the description of the research projects to fit our available space.

We have also attempted to determine an anticipated completion date (ACD) for each project. The anticipated completion date is the estimate of the date when the author will complete his report; additional time should be anticipated until the report is published. *If you wish more information on a project described herein, please write directly to the author; most of these projects will not be published by the Pennsylvania Geological Survey inasmuch as most are not Survey sponsored projects.*

The listings are grouped into major categories of research to facilitate your search for information on a particular subject. Reports published are listed alphabetically by author.

As with all compilations, there may be omissions; this is unintentional. Additional copies of this report may be obtained by writing to the Bureau of Topographic and Geologic Survey, Department of Environmental Resources, P.O. Box 2357, Harrisburg, Pennsylvania 17120.

AREAL GEOLOGY

T. M. BERG and **W. D. SEVON,** Pa. Geol. Survey, and **ROBIN ABEL,** Defense Mapping Agency. Rock Types of Pennsylvania. This map is a simplified version of the State Geologic Map and will be issued at the scale of 1:500,000. It will show the distribution of 19 different categories of rock in the Commonwealth. It will be useful for schools, tourists, and lay persons not familiar with the intricacies of stratigraphy. ACD: 1984.

BRUCE CUSHING and **G. H. MYER,** Temple Univ. The Martic Line, Coatesville, Unionville, and Norristown Quads. ACD: Dec. 1985.

A. J. FROELICH, Project Chief, U.S. Geol. Survey. Early Mesozoic Evolution of the Eastern U.S. During FY 1984, maps showing the following features of exposed early Mesozoic basins of the eastern U.S. will be compiled: distribution, lithology, and age of sedimentary rocks (Triassic-Jurassic), igneous rocks, Mesozoic and younger faults, and thermally metamorphosed rocks. Existing large-scale (1:24,000–1:62,500) geological and geophysical maps within the study area will be identified and evaluated and a list of references compiled. ACD: FY 1987.

J. D. INNERS, Pa. Geol. Survey. Geology and Mineral Resources of the Allenwood and Milton Quads., Union and Northumberland Cos., Pa. ACD: 1984.

T. J. KUNTZ and **N. K. FLINT,** Univ. of Pitt. A Regional Study of the Vanport Limestone in Elk Co. Miscorrelations of the Vanport in Elk County are being resolved while the extensiveness of it is becoming realized. A petrographic study reveals a heavy concentration of fossil algae in this limestone. ACD: Sept. 1984.

B. P. KOHN, Ben Gurion Univ./Univ. of Pa., and **M. E. WAGNER** and **T. M. LUTZ,** Univ. of Pa. The Cooling and Uplift History of the Central Appalachian Piedmont as Revealed by Fission-Track and Rb-Sr Studies of the Crystalline Basement [Piedmont from Baltimore area to Reading Prong and N.J. Highlands—includes all of Del. and Pa. Piedmont]. We plan to determine fission-track ages on apatite, zircon, and sphene and Rb-Sr ages on micas and whole rock from metamorphic basement rocks of the Piedmont of Pa.-Del.-Md. and the Reading Prong of N.J. and Pa. Since the minerals have different closure temperatures they are expected to yield discordant ages that can be interpreted in terms of uplift and cooling rates of the host rocks. ACD: Fall 1985.

P. T. LYTTLE, Project Chief, U.S. Geol. Survey. Newark 2-Degree Quad. This project was completed in FY 1983; a bedrock geologic map of the Newark 2-degree quadrangle is in press.

PETER LYTTLE and **J. B. EPSTEIN,** U.S. Geol. Survey, and **GARY LASH,** S.U.N.Y., Fredonia. New Tripoli 7-½′ Quad. Great Valley section has been mapped; Valley and Ridge mapping is underway on a part-time basis. ACD: 1986.

M. L. O'NEILL, Shippensburg Univ., and **T. M. BERG,** Pa. Geol. Survey. Geologic Map of Tidioute 15-Minute Quad. Recompilation of bedrock geology in Tidioute 15-minute quadrangle, being done as a graduate internship project. Aerial photo interpretation and evaluation of geophysical logs are being used to compile the geology at 1:24,000 scale.

ECONOMIC GEOLOGY

S. W. BERKHEISER, JR., Pa. Geol. Survey. High-Silica Deposits in Pennsylvania. Potential high-purity silica sources from nine Paleozoic formations and six quartz veins were sampled, chemically analyzed, and described from 30 locations representing 14 counties in central and eastern Pa. Percent Al_2O_3 and Fe_2O_3 are reported for as-collected and beneficiated splits. Beneficiation consisted of hot acid baths and magnetic separation. Potential resources for various manufactured silica products have been identified.

S. W. BERKHEISER, JR., Pa. Geol. Survey. Pa.'s Slate Industry: Alive and Well [Lehigh, Northampton, and York Cos.]. The Lehigh-Northampton slate district is unique in that in addition to producing flagging, flooring tiles, blackboards, roofing, and structural slates, it is the only U.S. producer of electrical and billiard slates. This district produces over $4 million worth of slate products annually while the Peach Bottom district remains idle. The geology, mineralogy, mining, milling, and marketing of Pa.'s slate industry is summarized. ACD: 1984.

S. W. BERKHEISER, JR., Pa. Geol. Survey. Some Fetid Barite Occurrences in Berks Co., Pa. Float mapping of about 6 sq mi (15 km^2) has resulted in identification of fetid, dark-gray, nodular-like barite mineralization and host rock relationships. Interpretations of paragenesis, age, exploration geochemistry, and environments of deposition are presented. Reconnaissance geologic maps are included.

S. W. BERKHEISER, JR., Pa. Geol. Survey, and **J. A. AMES,** Consultant. Chapter 42D, Limestone-Dolostone: Specialty Uses, *in* The Geology of Pennsylvania. The carbonate rocks of Pa. have played a long and historic role in the industrial and agricultural development of the state and nation. Limestones and dolostones represent about 80 percent of all rocks currently mined in the Commonwealth. The distribution and uses of the carbonate rocks will be summarized by physiographic province, and a brief historical perspective of carbonate mining in Pa. will be presented. High-purity carbonates will be emphasized.

S. W. BERKHEISER, JR., and **J. H. BARNES,** Pa. Geol. Survey. Directory of the Non-Fuel Producers in Pa. This compilation will provide a directory of the approximately one-half billion dollar non-fuel mineral industry in Pa. Mineral commodity, county, and producer listings are anticipated which would include addresses, telephone numbers, list of products, producing formations, and lithologies. A location map at a scale of 1:500,000 is proposed. ACD: 1985.

S. W. BERKHEISER, JR., and **J. H. BARNES,** Pa. Geol. Survey. Chapter 42B, Clay and Shale, *in* The Geology of Pennsylvania. The geology, mineralogy, and distribution of Pa.'s clay and shale mining industry will be summarized. Construction markets for this resource include impermeable barriers, pottery, bricks and tile, lightweight aggregate, borrow and fill material, and sources of Al_2O_3 for cement manufacture. Pa.'s high-alumina clay is noted for its refractory qualities. A compilation of white-clay sources is anticipated. ACD: 1985.

R. M. BORKOWSKI, Pa. State Univ. Facies Relationships and Associated Reservoir Characteristics of the Lower Devonian "Oriskany Sandstone" in the Appalachian Basin. The project consists of petrographic analysis of facies variations as well as porosity and permeability relationships. Samples have been obtained from 57 wells to date, mainly consisting of cored intervals along with a few cable tool cuttings. ACD: Aug. 1985.

E. C. T. CHAO, Project Chief, U.S. Geol. Survey. Coal Petrochemistry and Related Investigations. The development of methods to provide the most rapid, precise, and accurate quantitative petrographic description of coal samples will continue in FY 1984. Preparation of a report on the micro-characterization of arsenic- and selenium-bearing pyrite in the Upper Freeport coal, Indiana Co., Pa., is planned. ACD: FY 1985.

S. H. B. CLARK, Project Chief, U.S. Geol. Survey. Geology and Resources of Barite. Barite nodules in shales of the Appalachian basin were studied in FY 1983 in Bedford County, Pa., and west-central Va. These studies will be expanded to include similar localities in W.Va. and additional localities in Pa. A map showing the zinc, lead, and barite deposits in Paleozoic sedimentary rocks of the east-central U.S. has been completed and is currently in review. ACD: FY 1987.

WALLACE DE WITT, Project Chief, U.S. Geol. Survey. Stratigraphy of Devonian Black Shales in the Appalachian Basin. Oil samples will be collected in FY 1984 from the Lower Mississippian Berea Sandstone, which overlies the Devonian black shale sequence in

Ky., Ohio, and W.Va., and from Upper Devonian sandstones in N.Y., Pa., and W.Va. These samples will be compared with the hydrocarbons in black shales from cores cut by the Dept. of Energy to determine by chemical analyses if the shales were the source beds for the oils in the adjacent sandstones. ACD: FY 1986.

A. D. GLOVER, C. H. DODGE, J. G. PHILLIPS, D. R. SANDS, J. R. SHAULIS, and **V. W. SKEMA,** Pa. Geol. Survey. Coal Resources of Western Pa. Data for coal-bearing strata in Fayette, Westmoreland, Cambria, Blair, and Butler Cos. have been submitted for entry in the National Coal Resources Data System (NCRDS). Information for Clarion, Venango, Mercer, and Somerset Cos. is currently being assembled for entry into the system. This program will result in computer-generated resources maps and tables for western Pa. ACD: Data entry, 1987.

J. A. HARPER, Pa. Geol. Survey. Lineaments and Shale Wells: Another Look at the Devonian Shale Potential of Northern Erie Co. Plotting of Devonian shale wells in and around Erie indicates the highest open flows occur along well-defined linear trends—but not the lineament intersections recommended by a federally sponsored project. ACD: 1984.

J. A. HARPER and **C. D. LAUGHREY,** Pa. Geol. Survey. Geology of the Oil and Gas Fields of Southwestern Pa. [all of the Commonwealth south of the Ohio River and west of the Monongahela River]. Stratigraphy, structure, petrography, geochemistry, and engineering aspects of the oil and gas fields of Beaver, Allegheny, Washington, and Greene Cos. A summary history of the fields is included. ACD: 1984.

D. H. KRINSLEY, Ariz. St. Univ., **JACK DONAHUE,** Univ. of Pitt., and **C. D. LAUGHREY,** Pa. Geol. Survey. Application of Backscattered Electron Microscopy in Tight Sandstone Reservoir Characterization. Lower Silurian and Upper Devonian tight gas sands from western Pennsylvania have been examined in thin section by scanning-electron microscopy using backscattered electrons. Using backscatter, it is possible to identify individual rock constituents by their atomic number (z) contrast and differential hardness (relief). Information relating to texture, pore geometry, internal structure, and diagenetic history of the rock can be correlated to producing characteristics. ACD: June 1984.

C. D. LAUGHREY and **R. M. HARPER,** Pa. Geol. Survey. Atlas of Pa. Oil and Gas Reservoirs [covers all oil- and gas-producing areas of the state]. An illustrated compilation of geologic, engineering, and production data on the various petroleum reservoirs developed in

Pa. Reservoirs within different geographical areas will be grouped into plays on the basis of stratigraphy and structure. ACD: June 1986.

D. B. MacLACHLAN, Pa. Geol. Survey. (A) Anthracite Resources of Conyngham Quad.; (B) Computer Program for Anthracite Resources Computation and Reporting. Conyngham quadrangle anthracite resources are on open file at the Pa. Geol. Survey. The computer program running under CP/M (about 300K of disk space required) will be open filed when complete. ACD: Program, Aug. 1984.

G. R. ROBINSON, Project Chief, U.S. Geol. Survey. Metallogeny of the Early Mesozoic Basins of the Eastern U.S. An annotated bibliography for eastern U.S. Mesozoic basins will be completed during FY 1984. A data file on Mesozoic rock samples and locations that have been characterized (petrology, mineralogy, chemistry, isotope study, age dating, etc.) by various researchers in the U.S. Geological Survey will be developed. Compilation of mineral occurrence/ore deposit maps at 1:125,000 scale covering the exposed eastern U.S. Mesozoic basins will begin. Studies of mineralization associated with Mesozoic fault zones will be initiated. The geochemical signatures of eastern Mesozoic basalts will continue to be investigated. ACD: FY 1988.

J. B. ROEN, Project Chief, U.S. Geol. Survey. Source Bed Evaluation of Middle and Upper Ordovician Black Shale Facies of the Appalachian Basin. Collection of Paleozoic black shales from the Appalachian basin for geochemical analysis for source bed potential will continue in FY 1984. Devonian shales and oil samples will be collected for geochemical fingerprinting to determine oil source and migration paths. Subsurface data will be evaluated and used to determine the stratigraphy and distribution of Ordovician shales. ACD: FY 1985.

F. E. SENFTLE, Project Chief, U.S. Geol. Survey. Magnetic and Luminescence (DC). A magnetic technique has been developed to study the oxidation of coal. It has been found that by heating coal in an anoxic atmosphere, the pyrite can be partially converted to magnetite, thus making the grains magnetic. Tests have been made primarily on Pa. coals. In FY 1984, this work will be continued in cooperation with the U.S. Dept. of Energy Research Center in Bruceton, Pa. Along with the magnetic measurements, sulfur dioxide and oxygen evolution will be monitored to better establish the chemical changes during pyrite and coal oxidation. Most of the tests will be done with Pa. coals. ACD: FY 1985.

W. D. SEVON, Pa. Geol. Survey. Sand and Gravel Resources of North-Central Pa. [Potter, Tioga, Bradford, Susquehanna, and

Sullivan Cos.]. Mapping, sampling, and testing of sand and gravel deposits. ACD: Dec. 1986.

R. C. SMITH, II, and **J. H. BARNES,** Pa. Geol. Survey. Geologic and Mineralogic Interpretation of Gamma-Ray Reconnaissance for the Reading Prong, Eastern Pa. [portions of Berks, Bucks, Lehigh, and Northampton Cos.]. Study of the petrologic and geographic distribution of uranium and thorium mineralization is continuing, with several relationships emerging. ACD: Late 1984.

R. W. STINGELIN, Resource Technologies Corp., and **D. M. BARR,** Consultant. User's Manual for the Remaining Anthracite Coal Resources Computer Program (CALCOAL) [Pa. anthracite region]. Companion volume to "Defining the Anthracite Resources of Northeastern Pennsylvania" presents the methodologies and instructions for exercising the remaining coal resources algorithms (CALCOAL) and documents access to the anthracite data base. Describes how to prepare remaining anthracite coal resource estimates and how to distribute these spatially and by depth categories, and includes estimates of stripping ratios to 300 feet. ACD: Aug. 1984.

R. W. STINGELIN and **J. R. KERN,** Resource Technologies Corp. Defining the Anthracite Resources of NE Pa. ACD: Aug. 1984.

ENGINEERING GEOLOGY AND ENVIRONMENTAL GEOLOGY

ROY BLICKWEDEL, U.S. Geol. Survey. Ground-Water Quality as Related to Land Use Near Philadelphia, Pa., and Camden, N.J. This project will be conducted under the U.S. Geol. Survey national ground-water quality appraisal program. Emphasis will be to develop a data base for trace elements and organics. The information will be used to explain the chemistry by land use and local hydrology. ACD: Mar. 1985.

ROY BLICKWEDEL, U.S. Geol. Survey. Neshaminy State Park Soil Rejuvenation Study. In cooperation with the Pa. Bur. of State Parks, the U.S. Geol. Survey is conducting monthly ground-water quality sampling and analysis to determine the environmental effects of a synthetic soil application using mixtures of Delaware River dredge material, Philadelphia sewage sludge, and wood chips. ACD: Nov. 1984.

J. A. CICIARELLI, Pa. State Univ. Decay Rates of Carbonate Dimension Stone in SW Pa.

A. R. GEYER, Pa. Geol. Survey, and **W. H. BOLLES,** Pa. Dept. of Education, Bur. of Curriculum and Instruction. Outstanding Scenic Geological Features of Pennsylvania, Part 2. More than 150 new geologic features of outstanding significance will be included in Part 2. ACD: 1985.

J. V. HAMEL, Hamel Geotechnical Consultants, **H. M. FAUSOLD** and **C. E. STEVENSON,** Pbg. District, U.S. Army Corps of Engineers. Bank Instability on the Monongahela River, Pa. Bank instability and erosion are being investigated at six sites along the Monongahela River 92 to 103 km upstream from Pittsburgh. Bank degradation is a complex process involving numerous geotechnical and hydraulic interactions in bank soils. ACD: 1985.

J. D. INNERS, Pa. Geol. Survey, **J. H. WILLIAMS,** U.S. Geol. Survey, and **A. M. STERNAGLE,** Pa. Dept. of Transportation. Environmental Effects of Abandoned Clinton Iron-Ore Mines in Central Pa. ACD: Fall 1984.

STEVE OBERMEIER, Project Chief, U.S. Geol. Survey. Slope Movement and Drainage, Appalachians. A report on slope stability in the Appalachian Plateau will be submitted for review. ACD: FY 1986.

A. A. SOBEK and **J. P. SCHUBERT,** Engineers International, Inc. Pre-Mine Prediction of Acid Drainage Potential. Determination of which overburden analysis techniques commonly used can best be employed to predict water quality on reclaimed surface mines. Thirty research sites in bituminous fields of Pa. and four other states have been included. Correlation between overburden analysis data and post-mining water quality will be attempted. ACD: July 1985.

ROBERT WEISS and **N. K. FLINT,** Univ. of Pitt. Landslide Hazards in Penn Hills Twp., Allegheny Co. ACD: Fall 1984.

E. G. WILLIAMS and **JOEL MORRISORI,** Pa. State Univ. Relation of Pyrite Morphology to Production of Acid Mine Drainage [western Pa.]. Pyrite morphology is related to paleoenvironments as follows: brackish shales—all framboidal; freshwater shales—all euhedral; marine—both euhedral and framboidal. ACD: Dec. 1985.

J. P. WILSHUSEN, Pa. Geol. Survey. Subsidence in Carbonate Terrain, *in* The Geology of Pennsylvania [limestone regions of Pa.]. Carbonate rock, carbonate rock weathering, and foundation problems associated with carbonate terrain will be described. ACD: 1984.

J. P. WILSHUSEN and **H. L. DELANO,** Pa. Geol. Survey. Landslide Susceptibility in the Williamsport 1° x 2° Map Area, Pa. A map and text outlining landslide occurrences in the project area and relating them to geologic and topographic conditions. Through a computer program, 17 aspects of each landslide will be analyzed to determine relationships among causes. ACD: 1984.

GENERAL GEOLOGY

JACK DONAHUE and **J. M. ADOVASIO,** Univ. of Pitt. Archaeological Mitigation of Bridge Pier, Catawissa Creek, Columbia Co. Areal geology, sedimentation, soils, and archaeology of material found at site. ACD: Summer 1984.

JACK DONAHUE and **J. M. ADOVASIO,** Univ. of Pitt. Archaeological Mitigation of Texas Eastern Pipeline Corridor, Berks Co., Pa. Areal geology, soils, and archaeological sites along pipeline corridor. ACD: Summer 1984.

C. H. SHULTZ, Pbg. Geol. Soc./Slippery Rock Univ., and **R. P. BRIGGS,** Pbg. Geol. Soc./Geomega, Inc., eds. The Geology of Pennsylvania. More than 70 geoscientists have agreed to write for this encyclopedic compilation of the known geology of Pa. Manuscripts are to be submitted for review and editing by Aug. 1984. ACD: Jan. 1987.

GEOCHEMISTRY

CHARLES CRAVOTTA and **A. W. ROSE,** Pa. State Univ. Lateral and Temporal Variability of Pb, Zn, SO_4 and Other Elements in Ground Water in the Vicinity of Pb-Zn Prospects in Sinking Valley, Blair Co., Pa. Water from all available wells and seepages in upper Sinking Valley has been analyzed for major constituents, Pb, Zn, SO_4, F, Ba, Sr, and other properties, and two wells have been sampled weekly for a year, in order to understand the extent and variability of water anomalies. ACD: Dec. 1984.

B. C. HEARN, Project Chief, U.S. Geol. Survey. Geology of Kimberlite. Reconnaissance study and sampling of eastern U.S. kimberlites and alkalic intrusions in Md., Va., Pa., W.Va., and Ky. will continue.

J. M. McNEAL, Project Chief, U.S. Geol. Survey. Geochemical Studies in Eastern Triassic Basins. Preliminary work of the project will be to assess the use of the sulfur isotope composition of both diabase and evaporite deposits in Triassic sediments in the eastern U.S. as a potential geochemical exploration tool. In addition, the trace-element chemistry of the diabase will be examined. Particular attention will be paid to the Gap Nickel deposit, which may be a Noril'sk-type deposit, and to Cornwall-type deposits. ACD: FY 1988.

J. E. TILLMAN, Target Exploration, Inc. Surface Techniques for the Direct Detection of Oil and/or Gas Reservoirs [Pa. Appalachian Plateaus and Valley and Ridge provinces].

GEOMORPHOLOGY

K. F. CONNORS and **T. W. GARDNER,** Pa. State Univ. Use of Simulated-SPOT Data for the Study of Hydrologic Transport Processes in a Region Disturbed by Coal Mining [remote sensing, central Pa.]. Simulated-SPOT (Systeme Probatoire d'Observation de la Terre) imagery is being used to discriminate between coal mine spoil types and vegetative covers, and to identify acid mine drainage in central Pa. ACD: Jan. 1985.

J. J. GRYTA and **T. W. GARDNER,** Pa. State Univ. Erosion and Drainage Development on Reclaimed Coal Strip Mines in Central Pa. Gullies and accelerated erosion on reclaimed strip mines occur on convex-outward slope shapes. The amount of sediment eroded largely depends upon gully channel slope and both intensity and timing of storm events. ACD: Aug. 1984.

TERESA KAKTINS and **T. W. GARDNER,** Pa. State Univ. Fluvial Terraces of the Juniata River, Central Pa. [main river below Alexandria, Pa.]. Fluvial gravel deposits up to approximately 180 feet above the river will be correlated and their geomorphic expression described. An effort will be made to explain the origin of the diamicton texture generally observed in the deposits. ACD: 1984–85.

G. H. THOMPSON, JR., Elizabethtown Coll. Geomorphic Changes in the Lower Susquehanna River System. Presumed high discharges from Pleistocene glacial melting are hypothesized to have obliterated a falls/rapids stretch near Holtwood, Pa. "Hanging" tributaries and "deeps" are analyzed and compared with those at The Great Falls of the Potomac. ACD: Spring 1985.

W. B. WHITE, Pa. State Univ. Caves of Pa. The ultimate objective is a complete compilation of descriptions and maps of all caves in Pa. The past year was devoted to the cave survey of Bedford Co. ACD: 1984.

W. B. WHITE and **E. L. WHITE,** Pa. State Univ. Karst Landform Development in the Appalachian Highlands. Objective is to describe karst landforms (closed depression features, deranged drainage systems, and caves) by mathematical models and to interpret the descriptive models by geochemical models based on mass transport and dissolution kinetics. ACD: Ongoing.

GEOPHYSICS

J. M. DE NOYER, Project Chief, U.S. Geol. Survey. State

Geophysical Maps. Preparation of gravity and magnetic maps of Pa. and N.J. will be initiated. ACD: FY 1987.

JEFFREY PHILLIPS, Project Chief, U.S. Geol. Survey. Geophysical Mapping of Early Mesozoic Basins. Digital magnetic, aeroradiometric, and gravity data for the exposed early Mesozoic basins of the eastern U.S. from the U.S. Geological Survey, other federal agencies, state governments, and university sources will be assembled during FY 1984. Preliminary gravity anomaly map for the Gettysburg basin is among those being prepared. ACD: FY 1987.

R. E. SHERIDAN and **M. W. EISNER,** Univ. of Del. Geophysical Modeling of "Martic Line" and "Mine Ridge" Regions: Lancaster Co., Pa. Gravity and magnetic measurements will be analyzed and computer models made. For the Martic Line and Mine Ridge structures, structural interpretations will be made in light of new concepts of a rootless Piedmont. ACD: Aug. 1985.

GLACIAL GEOLOGY

D. D. BRAUN, Bloomsburg Univ. of Pa., and **WILLIAM BRENNAN,** Geneseo St. Coll. Development of a Record of Secular Variation of Geomagnetic Declination to Test the Age of the Kent Moraine [northern Potter and Tioga Cos. and southern N.Y.]. Glacial-deposit mapping, sampling of rhythmites, and determination of geomagnetic declination is being carried out to correlate ice-margin positions from one major valley to the next. The Genesee Valley was mapped in 1983 and the Cowanesque Valley will be mapped in 1984. ACD: Mid-1985.

D. D. BRAUN, Bloomsburg Univ. of Pa., and **J. D. INNERS,** Pa. Geol. Survey. Pre-Wisconsinan Glacial Deposits and Ice Margin Positions in the Valley and Ridge Province of Eastern Pa. Examination of strip mine exposures and seismic refraction work are being used to delineate areas of anomalously thick drift. Work to date suggests an ice margin running parallel to but a few tens of kilometers in front of the Woodfordian margin. ACD: 1987(?).

BENJAMIN LESLIE-BOLE, Univ. of Del. A Depositional Analysis of Deltaic and Lacustrine Sediments from Glacial Lake Sciota, Monroe Co., Pa. ACD: Nov. 1984.

W. D. SEVON, Pa. Geol. Survey. Glacial Geology of the Upper Susquehanna River [Potter, Tioga, Bradford, Susquehanna, and Sullivan Cos.]. Project involves detailed reconnaissance mapping of the surficial geology at a scale of 1:24,000. ACD: Dec. 1986.

HYDROLOGY

GERT ARON, E. L. WHITE, D. F. KIBLER, DAVID WALL, and **GARY BRUNNER,** Pa. State Univ. Comparison of Rainfall/Runoff Simulation Model Performance [Brandywine Creek (Pa.), Fletcher Creek (Tenn.), Wye and Severn Creeks (England)]. Three hydrologic models for simulating runoff hydrographs from rainfall—PSRM (Pa. State Runoff Model), HEC-1 (Hydrologic Engineering Center, Davis, Calif.), and MILHY (Military Hydrologic Model, Corps of Engineers)—are being tested on four major river systems. ACD: Mar. 1985.

A. E. BECHER, U.S. Geol. Survey. Ground-Water Resources of Cambrian and Ordovician Carbonate Rocks in the Valley and Ridge Province in Pa. [700 sq mi]. Detailed hydrologic information is being gathered to evaluate the ground-water resources of the carbonate valleys on the west side of the Valley and Ridge province. Objectives also include evaluation of nitrate contamination and estimation of drought effects on water levels. ACD: June 1986.

W. F. EBAUGH, W. R. GOUGH, and **B. A. WAITE,** Moody and Associates, Inc. Aquifer Dewatering for Control of Drainage into a Deep Coal Mine [Indiana Co.]. Goal is to reduce water drainage through the mine roof by pumping of wells sited on fractures which act as avenues along which vertical flow is concentrated. ACD: Sept. 1984.

J. M. GERHART, P. L. LIETMAN, and **D. K. FISHEL,** U.S. Geol. Survey. Effects of Agricultural Best Management Practices on Nonpoint-Source Discharges in the Conestoga River Basin above Lancaster, Pa. The effects of agricultural best management practices on the concentrations and loads of sediment and nutrients in both ground and surface waters will be evaluated on regional, small watershed, and field scales. ACD: 1991.

D. W. JORGENSEN and **T. W. GARDNER,** Pa. State Univ. The Runoff Potential and Hydrologic Character of Reclaimed Coal Surface Mines in Central Pa.; Measurement and Simulation. ACD: Jan. 1985.

J. E. MANDUKE, III, Pa. Dept. of Environmental Resources, Bur. of Solid Waste Management. Contaminant Transport in Land Disposal Facilities [southeastern Pa.]. Study of delineation of contaminant plumes and species variability relationships spatially in an aquifer—including industrial solvents, hazardous constituents, and priority pollutant behavior in the subsurface. ACD: Jan. 1985.

T. A. McELROY, Pa. Geol. Survey. Groundwater Resources of Cambria Co. The project will provide a description and inventory of groundwater resources in Cambria Co. Two stream stage gages have been installed and well inventory is complete. ACD: June 1985.

T. A. McELROY, Pa. Geol. Survey. Groundwater Resources of Fayette Co. The project will provide a description and inventory of groundwater resources in Fayette Co. ACD: 1984.

R. T. PAULSEN, U.S. Geol. Survey. A Model of Ground-Water Flow in the Carbonate Rock of the Little Lehigh Creek Basin, Lehigh Co., Pa. A 2-D digital ground-water flow model of the carbonate aquifer system in the Little Lehigh Creek basin will be calibrated and, if possible, verified. ACD: Sept. 1986.

R. A. SLOTO, U.S. Geol. Survey. Effect of Urbanization on the Water Resources of Eastern Chester Co., Pa. ACD: Sept. 1985.

D. W. SPEIGHT, U.S. Geol. Survey, and hydrologists. Chemistry of Precipitation and Its Impact on Quality of Storm Runoff in Pennypack Creek, Phila., Pa. ACD: Sept. 1985.

D. W. SPEIGHT, U.S. Geol. Survey, and hydrologists. Water Resources of the Furnace Creek Basin, Berks, Lebanon and Lancaster Cos., Pa. ACD: Sept. 1985.

D. W. SPEIGHT, U.S. Geol. Survey, and hydrologists. Water-Table Contour Map of the Carbonate Rocks of Southern Chester Co., Pa. ACD: Dec. 1984.

MATTHEW WERHNER, Northampton Co. Area Comm. Coll. Summary Groundwater Resources of Northampton Co., Pa. ACD: Aug. 1984.

D. R. WILLIAMS, T. F. BUCKWALTER, J. K. FELBINGER, and **K. L. PATTISON,** U.S. Geol. Survey, and **V. W. SKEMA,** Pa. Geol. Survey. Washington Co. Water Resources Study. A comprehensive appraisal of both ground-water and surface-water resources throughout the county. To date, approximately 400 wells have been inventoried and six stream gaging stations are in operation. ACD: Mar. 1986.

J. H. WILLIAMS and **KENN PATTISON,** U.S. Geol. Survey, **R. R. PARIZEK** and **JEFF HENKE,** Pa. State Univ., and **ROGER HORNBERGER,** Pa. Dept. of Environmental Resources, Bureau of Mining and Reclamation. Evaluation of the Surficial Application of Limestone Quarry Waste in the Abatement of Acidic Drainage from a Coal Strip Mine Site, Clarion Co., Pa. ACD: 1987.

J. H. WILLIAMS, U.S. Geol. Survey, and **L. E. TAYLOR** and **W. D. SEVON,** Pa. Geol. Survey. Hydrogeology of the Glaciated Valleys of North-Central Pa. ACD: 1986.

IGNEOUS AND METAMORPHIC PETROLOGY

PAT BAKER and **G. H. MYER,** Temple Univ. The Martic Line, Parkesburg Quad. (Octoraro Creek "Type Section"). ACD: Dec. 1985.

A. L. HOERSCH, LaSalle Coll., and **W. A. CRAWFORD,** Bryn Mawr Coll. The Geology of the Mine Ridge, Southeastern Pa. ACD: Sept. 1986.

M. S. RUTSTEIN and **D. CONRAD,** S.U.N.Y., New Paltz. Thermal Maturation Patterns of Ordovician Miogeosynclinal Flysch of the N. Appalachians [Ordovician shales of eastern Pa.]. Authigenic "illites" provide a measure of the degree of thermal maturation. Preliminary work in eastern Pa. indicates a sharply westward flexure of regional thermal patterns. This most likely represents the transition from Lower Paleozoic to Alleghanian orogenic effects. ACD: Fall 1986.

PALEONTOLOGY

J. R. ANDERSON, JR., Univ. of Pitt. Microgastropod Biofacies of the Upper Carboniferous System in the Northern Appalachian (Dunkard) Basin. Objective is to update the taxonomy and determine the paleogeographical range of each microgastropod species, and to construct microgastropod biofacies maps. This is one step toward understanding the centers of origin and dispersion of Upper Carboniferous microgastropods. ACD: June 1985.

P. S. BOYER, Fairleigh Dickinson Univ. Scolecodonts from the Silurian-Devonian Formations of Eastern Pa. [Monroe Co.] and Northern N.J. [Sussex Co.]. Preliminary collections have uncovered well-preserved and abundant scolecodonts in several formations spanning the Silurian-Devonian boundary. Further collecting and laboratory work is underway in Monroe County. ACD: Spring 1986.

D. K. BREZINSKI, Univ. of Pitt. Carboniferous Trilobites from the Appalachian Basin [Ohio, Pa., W.Va., Md.]. The Appalachians represent the last region in the U.S. in which Carboniferous trilobites are poorly known. Their stratigraphic and paleoecological distribution is to be studied. ACD: May 1985.

D. K. BREZINSKI, Univ. of Pitt. Epizoan Ecology in the Wymps Gap

Limestone of SW Pa. [Indiana, Westmoreland, and Fayette Cos.]. The relationship between epibionts and their hosts will be studied. Also to be examined is the relationship of the different epibionts to depositional environment. ACD: June 1984.

R. M. BUSCH, Univ. of Pitt. New Trilobites from the Shriver Formation (Lower Devonian) of Central Pa. Ten species of nine different trilobite genera are described from the richly fossiliferous Upper Shriver trilobite beds of central Pa. There are new species of *Proetus, Harpidella, Trimerus, Odontochile, Synphoroides,* and *Leonaspis*. ACD: 1985.

W. F. KLOSE, II, Paleontological Research Inst. Contributions to the Pennsylvanian Age Flora and Fauna of the Anthracite and Semi-Anthracite Coal Fields of NE Pa. Collection of Pennsylvanian-age flora and fauna with deposition of prepared specimens in the William Penn Memorial Museum, Harrisburg. ACD: Ongoing.

W. F. KLOSE, II, Paleontological Research Inst. Fossil Flora and Fauna of the Ross Anthracite in the Northern Anthracite Basin, Pa. Specimens from the Larksville mine fire and Loree Colliery, Larksville, Pa., and Alden Mountain, Glen Alden, Pa., have been collected and prepared for study and illustration. ACD: July 1985.

W. A. OLIVER, Project Chief, U.S. Geol. Survey. Upper Silurian/Lower Devonian Biostratigraphic Framework of the Central Appalachians. Laboratory studies on the biostratigraphy and systematics of corals in the Decker-Helderberg interval of N.J. and Pa. and ostracodes of the Decker-Keyser interval in Md., Pa., and N.J. will be completed. Reports will be prepared on the Keyser-Helderberg interval in Pa., Md., Va., and W.Va., and on the Manlius and Coeymans ostracodes of N.Y. ACD: FY 1985.

W. A. OLIVER, JR., and **J. M. BERDAN,** U.S. Geol. Survey. Uppermost Silurian-Lower Devonian corals and ostracodes of the central Appalachians [N.Y. to Va.]. Pennsylvania part of project is a study of the systematics and distribution (stratigraphic and geographic) of corals and ostracodes in the Keyser, Decker, and Helderberg Limestones. ACD: 1986.

ALFRED TRAVERSE and **N. G. JOHNSON,** Pa. State Univ., and **P. K. STROTHER,** Boston Univ. Plant Fossils of Lower Silurian Rocks of Pa., Especially of the Tuscarora Formation [central Pa.]. Continuation of a long-term project on early Silurian land-plant evidence in Pa. Most of this year's work has dealt with the extensive Tuscarora outcrop near Mill Hall, on the geology of which Prof. Edward Cotter, Bucknell Univ., has also published. Detailed studies of sporelike bodies, including masses of tetrads, are providing interesting insights into the early stages of land plant evolution. ACD: Ongoing.

SEDIMENTOLOGY

J. S. BRIDGE and graduate students, S.U.N.Y., Binghamton. Sedimentology of Upper Devonian Catskill Clastic Wedge in N.Y. and Northeastern Pa. (1) Quantitative reconstruction of paleochannel geometry and hydraulics in fluvial Catskill magnafacies; (2) interpretation of depositional environments of Upper Devonian coastal lithofacies.

J. A. CONRAD, Univ. of Del. Shelf Sedimentation Above Storm Wave Base in the Upper Ordovician Reedsville Formation in Central Pa. Outcrop data on sedimentary structures, lithology, and fossils indicate that most fining-upward beds were deposited from suspension under conditions of strong but waning bed shear. Storm wave influence on a shallow, open shelf is inferred. ACD: Sept. 1984.

EDWARD COTTER, Bucknell Univ. Middle Silurian Depositional History, Central Pa.

BOB GALLAGHER, Lehigh Univ. Depositional Environments of the Loyalhanna Formation, Centre Co., Pa. ACD: June 1984.

B. V. GLOHI and **JACK DONAHUE,** Univ. of Pitt. Petrography of Upper Devonian Gas Bearing Sandstones in Well #1 1237 Ind 25084, Indiana Co., Pa. Petrographic analysis of gas-bearing Upper Devonian sandstones, including grain size, composition of grains and cement, and variation in void space. Analysis of geophysical logs in adjacent wells was also covered. ACD: Completed.

A. L. GUBER, Pa. State Univ. Facies Analysis of the Middle and Upper Silurian Formations of Central and Western Pa. A geochemical, paleontological, and sedimentological approach is being used to define facies sequences, prepare facies maps, and develop facies models for the Mifflintown, Wills Creek, and Tonoloway Formations. ACD: Continuing.

R. B. HOFFMAN, Susquehanna Univ. Depositional Environment and Regional Correlation of the Ridgeley Member of the Old Port Formation [Pa., Md., N.J., and N.Y.]. ACD: May 1984.

G. G. LASH, S.U.N.Y., Fredonia. Sedimentology of an Ancient Subduction Complex—Greenwich Slice of the Hamburg Klippe [eastern Pa.]. Results of recent DSDP (Deep Sea Drilling Project) transects across active subduction complexes are being applied to the study of the Greenwich slice. ACD: Early 1985.

G. G. LASH and **JEFFREY FILOCK,** S.U.N.Y., Fredonia. Late Cambrian Carbonate Submarine Fan Deposits—Sedimentology and Significance [eastern Pa.]. Sedimentologic analyses of the Onyx Cave Member (Hamburg klippe) suggest it was deposited as part of a submarine fan complex during a Late Cambrian-Early Ordovician regressive event. ACD: Late 1984.

C. D. LAUGHREY, Pa. Geol. Survey. Storm-Surge Genesis of Quartzose Turbidites in Upper Devonian Deltaic Deposits, Southwestern Pa. Complete and incomplete Bouma sequences have been recognized in association with Upper Devonian rocks of paralic on-delta origin. The sequences are common at outcrop localities and in subsurface cores. The sequences are interpreted as storm deposits. ACD: Aug. 1984.

TIM MURIN and **JACK DONAHUE,** Univ. of Pitt. The Upper Devonian First Bradford Sandstone of Southwestern Pa.: Environment of Deposition and Factors Affecting Gas Production. ACD: Spring 1985.

STRATIGRAPHY

T. M. BERG, Pa. Geol. Survey. The Devonian-Mississippian Transition in Pennsylvania, *in* The Geology of Pennsylvania. The chapter will summarize the Spechty Kopf, Huntley Mountain, and Rockwell Formations and their relationships to the marine Mississippian succession in western Pa. It will also summarize current understanding of the position of the Devonian-Mississippian systemic boundary in Pa. ACD: Mid-1984.

D. K. BREZINSKI, Univ. of Pitt. Dynamic Lithostratigraphy and Paleoecology of the Mauch Chunk Formation of Pa., W.Va., and Md. The depositional environments of the Mauch Chunk clastics and the associated marine tongues can be related to eustatic sea-level changes, variations of subsidence, and rates of clastic influx. ACD: May 1984.

R. M. BUSCH, H. B. ROLLINS, K.E. WELLS, and **D. K. BREZINSKI,** Univ. of Pitt. Correlation of Appalachian Carboniferous Strata Using a Hierarchy of Transgressive-Regressive Units [western and northeastern Pa.]. Carboniferous strata can be very accurately correlated relative to six scales of transgressive-regressive units (T-R units). ACD: 1984–85.

ROBERT CANACE, RICHARD DALTON, and **FRANK MARKEWICZ,** N.J. Geol. Survey, and **JOHN REPETSKI,** U.S. Geol. Survey. Stratigraphy of Cambro-Ordovician Kittatinny Supergroup in [northwestern] N.J. The New Jersey Survey is working with the U.S. Geol. Survey in an attempt to correlate Cambro-Ordovician carbonate units in Pa. with those in N.J. In order to do this, we will be examining and collecting carbonates in N.J. and Pa. in an attempt to relate conodont zonation to lithostratigraphy. ACD: Ongoing.

A. D. GLOVER, C. H. DODGE, J. G. PHILLIPS, D. R. SANDS, J. R. SHAULIS, and **V. W. SKEMA.** TASIC (Temporarily Available Stratigraphic Information Collection) [western Pa.]. A continuing program for recording stratigraphic data on active coal and clay strip mines and collecting coal samples for analysis. The project will provide data for future mapping and regional resource evaluation. ACD: Ongoing.

J. A. HARPER, Pa. Geol. Survey. Tully, or "Tully"—A Stratigraphic Problem. A review of the controversy surrounding the so-called Tully Limestone, especially in northwestern Pa., and an attempt to provide evidence for NOT rejecting the name Tully in that area. ACD: 1984.

K. E. WELLS, Univ. of Pitt. Detailed Correlation and Paleogeographic Development of the Upper Pennsylvanian Woods Run and Carnahan Run Marine Units in Pa. [central and southwestern Pa.]. Detailed facies analysis and correlation indicate that the Woods Run and Carnahan Run marine units are actually correlative, intertonguing facies of the same marine unit. They are not separate marine invasions as originally thought. ACD: 1984.

E. G. WILLIAMS, Pa. State Univ. Diagenesis of Upper Paleozoic Sandstones in Pa.

D. E. WISSINGER and **R. M. GOODSPEED,** Susquehanna Univ. Determination of Color Genesis in the Bald Eagle and Lower Juniata Sandstones in Blair Co., Pa. ACD: May 1984.

STRUCTURAL GEOLOGY

R. M. BOND, Lehigh Univ. Regional Tectonic Relations and Metamorphic Grade of the Martinsburg Formation in Eastern Pa. and N.J. [Northampton Co., Pa.]. Fluid inclusions in quartz from faults and veins were used to define the thermobarogeochemical conditions present during mineralization. Thrust faults and regional slaty cleavage appear to be Alleghanian structures. ACD: June 1984.

WAYNE BREWER, Allegheny Coll. Strain Measurement in the Appalachian Plateau, Northwestern Pa. ACD: Open-ended.

WALLACE DE WITT, JR., and **K. C. BAYER,** Project Chiefs, U.S. Geol. Survey. Thrust Plate Models of the Appalachian Orogen. A chapter on the structure under the Appalachian Plateaus of Pa. will be prepared for *The Geology of Pennsylvania,* a book sponsored by the Pittsburgh Geol. Soc. A chapter on the hydrocarbon resources of the Appalachian orogen, coauthored with R. C. Milici, State Geologist of Va., will also be prepared. ACD: FY 1985.

LARRY DUFFY and **G. H. MYER,** Temple Univ. The Martic Line, Malvern and Valley Forge Quads. ACD: Dec. 1984.

R. T. FAILL, Pa. Geol. Survey. Tectonic Map of Pa. Delineation of anticlines, synclines, and faults; portrayal of all igneous rocks; basement contours; structure contours on top of Onondaga in Plateau; delineation of lithotectonic units; tectonic provinces and age of deformation; unconformities; major fracture orientations; metamorphic isograds; radiometric dates; earthquake epicenters; cross sections. ACD: 1984.

P. GEISER, Univ. of Conn. Determination of Complete Displacement Field, Valley and Ridge and Plateau Provinces. ACD: 1987.

P. GEISER, Univ. of Conn., and **D. DALLMEYER,** Univ. of Ga. Collaborative Structural and Geochronologic Investigation of Alleghanian Deformational Events in the Central and Northern Appalachian Foreland. ACD: 1985.

R. M. HARPER, Pa. Geol. Survey. Subsurface Structure of the Plateau Region of North-Central and Western Pa. on Top of the Oriskany Formation. An update of Addison S. Cate's 1962 map (Mineral Resource Report 9 of the Pa. Geol. Survey). ACD: 1984.

MARK LUCAS and **WARREN MANSPEIZER,** Rutgers Univ. Fracture and Joint Patterns in the Mesozoic Jacksonwald Syncline of Berks Co., Pa. Field mapping of fracture patterns in the Jacksonwald Syncline may yield a viable model for the origin of deformation of this area. ACD: Dec. 1984.

D. B. MacLACHLAN, Pa. Geol. Survey. Tectonic Synthesis of Southeastern Pa. Project is in initial stages: input from outside is invited.

V. J. PFAFF, Univ. of Cinn. Mechanisms of Folding in the Central Appalachians, Pa. ACD: June 1985.

H. A. POHN, U.S. Geol. Survey. Structure of the Valley and Ridge Province Using Field and Remote Sensing Techniques. Lateral ramps (perpendicular to the fold belt) are strongly suspected along the Susquehanna River and at the Pa.-Md.-W.Va. borders. These ramps manifest themselves as abrupt changes in wavelength of folds along strike. ACD: Oct. 1984.

S. I. ROOT, Coll. of Wooster. Structural Geology of the Gettysburg Basin. ACD: Late 1984.

R. E. SHERIDAN, Univ. of Del. Structural Studies of Iapetus Continental Margin in Lancaster Co., Pa. Restoration of the Iapetus continental margin will be made based on structural and stratigraphic analysis of rootless and telescoped Piedmont rocks in light of new concepts of Appalachian structure. ACD: Aug. 1985.

D. W. WATSON, Slippery Rock Univ. Fracture Study of the McConnell's Mill Gorge, Lawrence Co., Pa. ACD: 1985.

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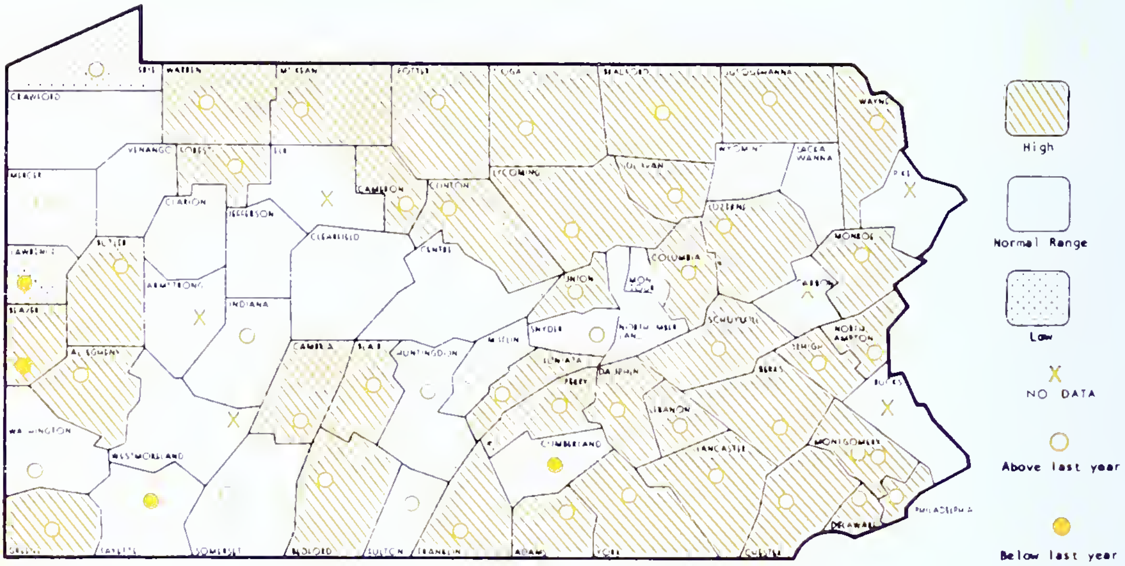

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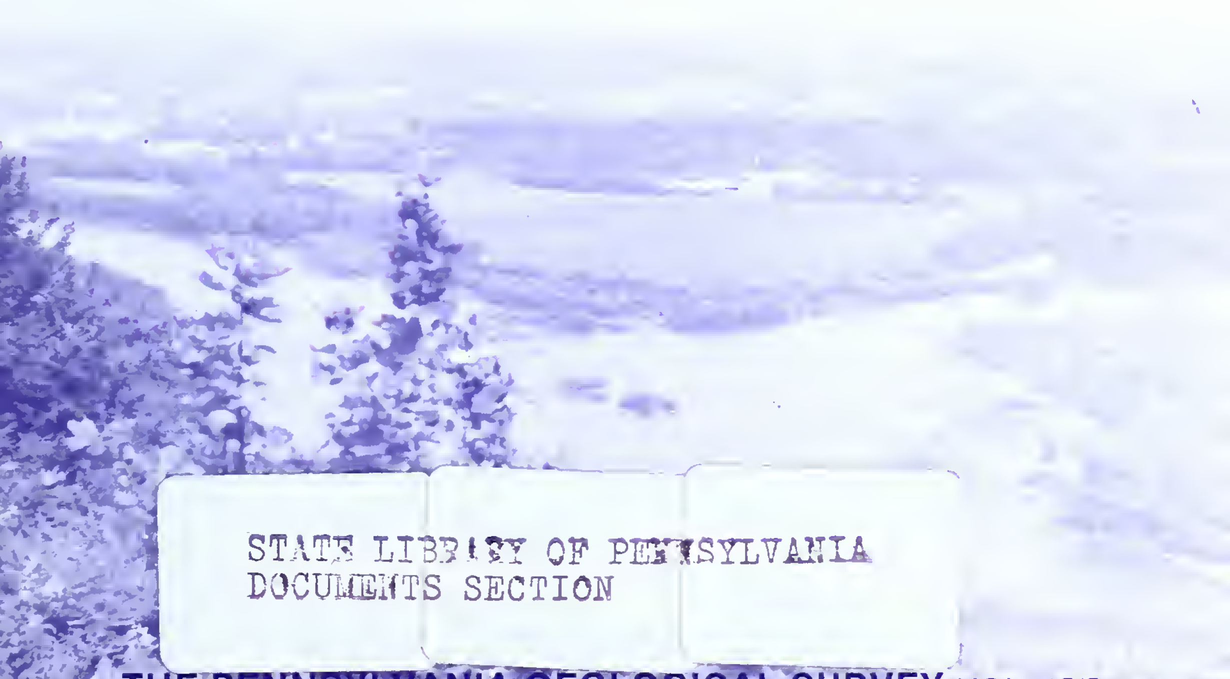

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ON THE COVER: Northwest view from Route 15 overlook near Williamsport, Lycoming County. Loyalsock Creek (at right) joins West Branch of Susquehanna River. Broad flood plain area (center of photo) is underlain by thick river-borne sand and gravel deposits. Allegheny Plateau forms the skyline in the photo.

PENNSYLVANIA GEOLOGY is published bimonthy by the Topographic and Geologic Survey, Pennsylvania Dept. of Environmental Resources, Harrisburg, Pennsylvania, 17120.

Editor, Arthur A. Socolow; Associate Editor, Donald M. Hoskins.

Articles may be reprinted from this magazine if credit is given to the Topographic and Geologic Survey.

VOL. 15, NO. 5 **OCTOBER, 1984**

FROM THE DESK OF THE STATE GEOLOGIST

"OIL IS FOUND IN THE MINDS OF MEN"

A major benefit of attending professional meetings is to learn of the interests voiced by colleagues active in our profession. This helps to guide the activities and direction of our Survey along paths for which there are demonstrated needs.

So it was stimulating to see an unexpectedly heavy turnout in Pittsburgh, early this month, where nearly 500 geologists attended the American Association of Petroleum Geologists' Eastern Section Meeting. Representing most of the major oil and gas companies, and coming from as far as California, Texas, and Colorado, the major item of interest on the three-day program appeared to be a series of technical discussions detailing the geologic conditions associated with deeper (e.g. Trentonian) formations of Pennsylvania and adjacent Appalachian states.

It is noteworthy that while this 1984 meeting of the petroleum society fell on the 125th anniversary of the successful completion of the Drake Well at Titusville (North America's first oil well), the thrust of the recent Pittsburgh meeting was directed towards the future of this Appalachian region.

The title of this article is borrowed from a famous quotation uttered many years ago by an illustrious petroleum geologist, Dr. Wallace E. Pratt, who eventually became President of the Standard Oil Company of New Jersey. The title exemplifies the creativity and optimism which was demonstrated by the petroleum geologists attending the Pittsburgh meeting. It bodes well for the future of Appalachian oil and gas production.

With sophisticated new exploration techniques and with exciting new concepts and interpretations of the structure and stratigraphy of the largely untested deep formations under Pennsylvania, it appears that petroleum geologists from throughout the country share our optimism for potential new oil and gas discoveries within our borders. Such reactions have helped to support and justify the investigations by our Oil and Gas Geology Division, based in Pittsburgh and dedicated to providing new insight to Pennsylvania's still untapped oil and gas resources.

Arthur A. Socolow

AN OUTSTANDING MINERAL PRODUCER

Martin Stone Quarries, Inc.

Located in eastern Berks County between Boyertown and Bechtelsville in Colebrookdale Township (Lat. 40°21′37″N, Long. 75°37′46″W), Martin Stone Quarries, Inc., is a unique southeastern Pennsylvania aggregate producer whose selective mining fills various product niches. Aspects of "Martin Stone" which make it a most interesting mining operation include: 1) a small, family owned and operated business, 2) the only active producer mining Precambrian age Reading Prong crystalline rocks in the Commonwealth, 3) one of a limited number of sources in southeastern Pennsylvania for high-friction coarse aggregate which is vital for safe roads, and 4) a source of economical clay-rich landfill cover and lining material for local municipal waste-disposal sites.

Harvey Nester first produced screened sandstone from this site in 1897 (Figure 1) at which time a buckboard load of "gravel" cost 25¢ (Glenn Martin, personal communication, 1984). Henry and Dorothy Martin first leased and produced stone from this site in the mid 1950's. Today, family holdings include about 200 acres and Henry's sons manage daily operations (Figure 2). However, Dorothy Martin still cheerfully greets all visitors and is a very active corporation secretary and treasurer.

Geologically, the surrounding terrain is complex. The folded and faulted Cambrian age Hardyston Formation nonconformably caps most of the higher elevations and also forms the underlying bedrock of some hills in the area (Buckwalter, 1959). Relief of this unconformity is unknown and complicated by even more complex geology of the older, underlying Precambrian age gneisses, which form the cores of large-scale, complex fold (alpine-type nappe) structures (Drake, 1978).

Clay-rich overburden (regolith and saprolite) on top of both the quartzite and gneiss, is used for infield sand on ball diamonds, cover and base liners for area landfills, and is a local source of general fill material.

The Cambrian age Hardyston Formation, characterized as a light-colored, locally feldspathic quartzite and sandstone, historically was

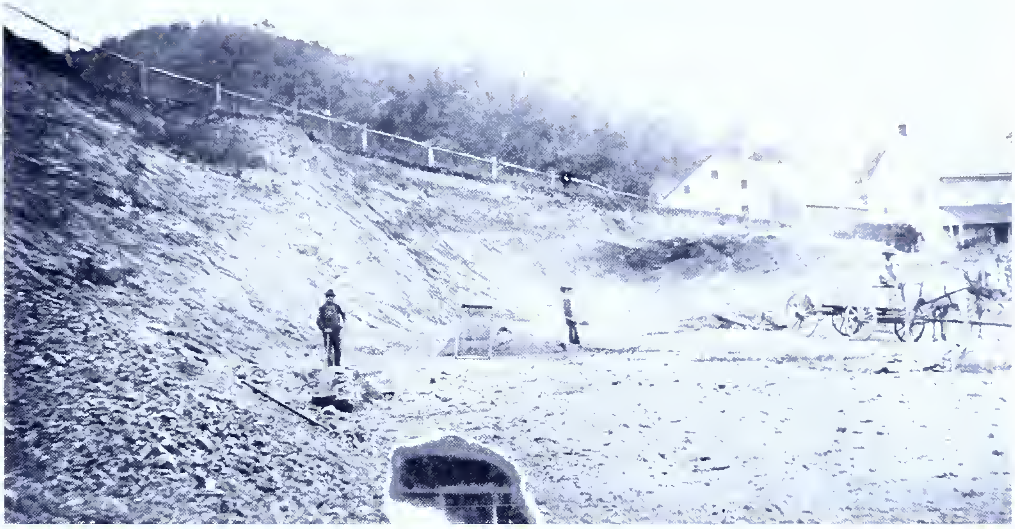

Figure 1. A 1912 photograph of the former Harvey Nester operation now owned and operated by Martin Stone Quarries, Inc. Notice the screening operation in the center of the photo. Original photograph courtesy of Glenn L. Martin.

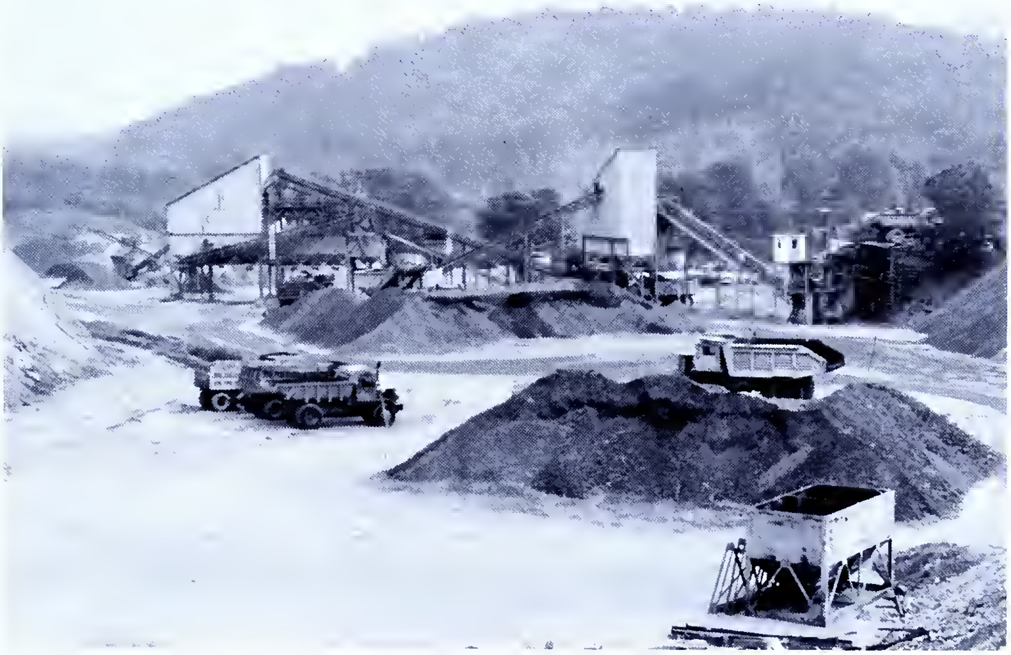

Figure 2. Would Harvey Nester recognize his operation 72 years later? Primary crusher is located to the right and quartzite face to the left.

the principle rock type mined. This quartzite is crushed into PennDOT-approved fine and coarse aggregate. The coarse aggregate produced from this quartzite is the only "approved" bedrock material mined in southeastern Pennsylvania that meets PennDOT's highest skid resistance level designation which is needed for surfacing bituminous roads with high traffic volumes. Because of the low number of alternative sources for this type of material, it is trucked to the Philadelphia market, a straight line distance of about 40 miles. This same quartzite is also used as an ingredient in mineral wool insulation produced from slag at Hellertown.

The Precambrian gneiss is the major rock type currently being mined. The exposed rock is characterized as a dark-colored hornblende-plagioclase gneiss containing accessory biotite. Similar rocks elsewhere have been designated amphibolite (Drake, 1984). These rocks, when crushed, also produced a good high-friction aggregate, but unlike the quartzite their use is restricted to roads with lower traffic counts. Minor lenses and discontinuous veins (up to 2½" wide) of white and pink barite contain minor calcite, trace amounts of pyrite, chalcopyrite, galena, and quartz.

Selective mining techniques have stretched the total reserves of this operation and conserved rock types for their highest end-use products. Recognizing the need to plan for future generations, this family owned corporation is currently involved in seeking zoning approval to mine a contiguous property. This issue should be resolved in such a way as to maximize the continued use of these valuable resources and have little or no adverse environmental impact. All parties certainly agree on the need for a source of the safest possible highway surfacing material available.

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THE LARGEST LANDSLIDE IN PENNSYLVANIA

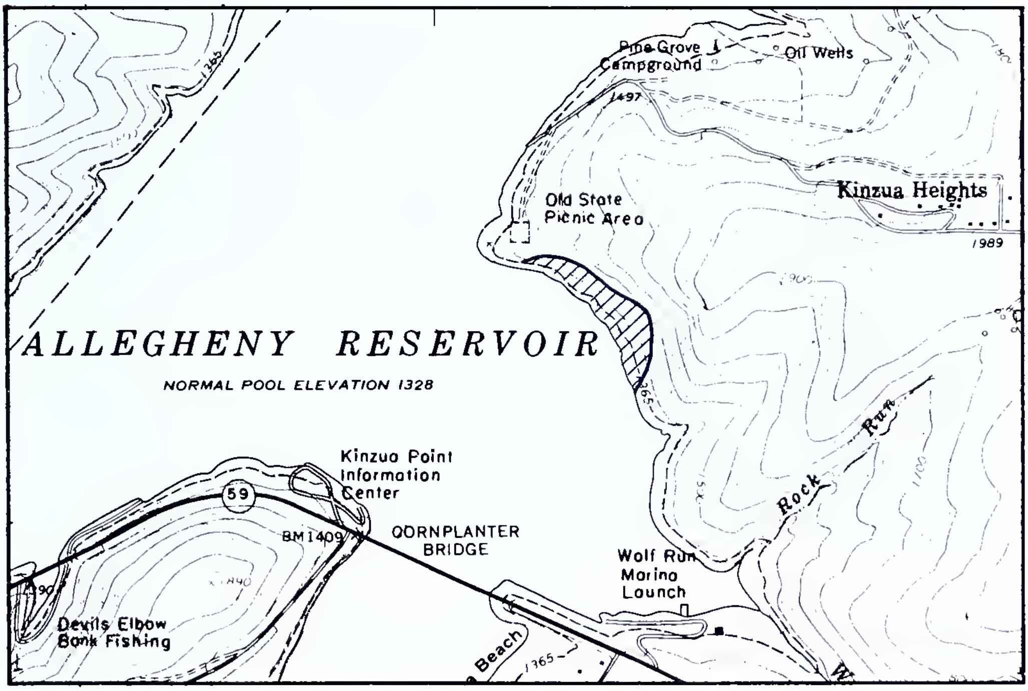
by Thomas K. Collins and Ruth D. Seeger
Allegheny National Forest

We offer a friendly challenge to the readers of PENNSYLVANIA GEOLOGY: find the State's largest landslide.

A landslide may be "large" in different ways: longest, widest, deepest, most volume of slide mass, most surface area. Subsurface investigations to determine depth and volume of slide mass usually are not available. But all readers have the opportunity to measure the surface of a landslide. So, we suggest three categories of "large":

1. surface area (measured by acres).
2. length (measured by maximum downslope distance from main scarp to the toe of the landslide).
3. width (measured by maximum distance, along elevation contour, between lateral scarps).

We also suggest the search be limited to *active* landslides. Active landslides show clear evidence (such as fresh scarps) of ground movement in recent years. The size or surface area of an active land-



slide usually is readily identifiable by the main scarp and by the border of the moving slide mass. In contrast, the recognition of old, inactive landslides and their boundaries can be subject to more interpretation.

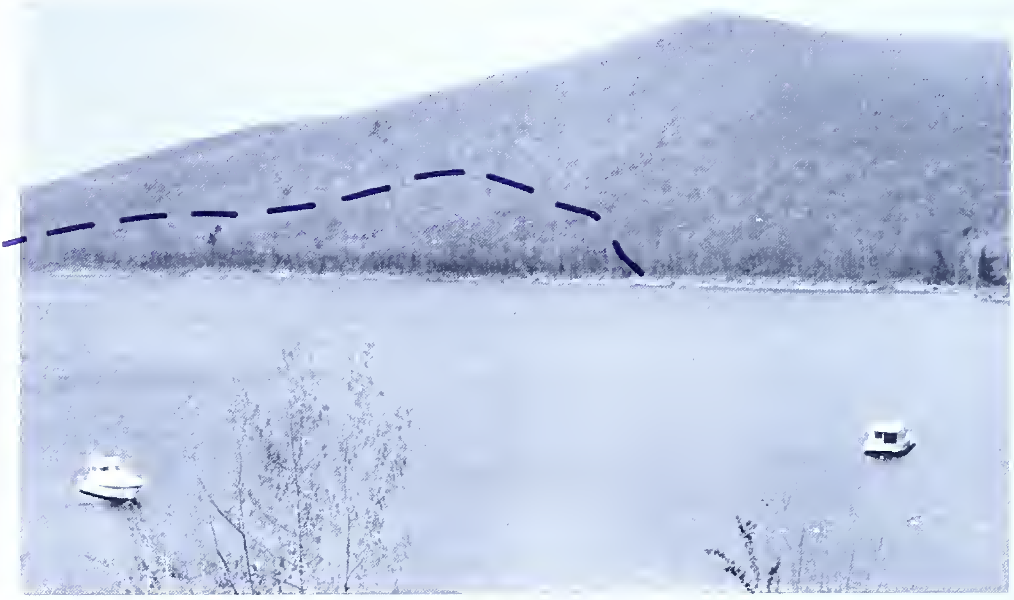
Our nominee for the largest landslide in Pennsylvania is the Kinzua landslide along the east shore of the Allegheny Reservoir in Warren County. To start the contest, we nominate the Kinzua landslide in all three size categories:

1. Its surface area is 14 acres.
2. Its downslope length is at least 560 feet.
3. Its width is 2,000 feet along the shoreline of the Allegheny Reservoir.

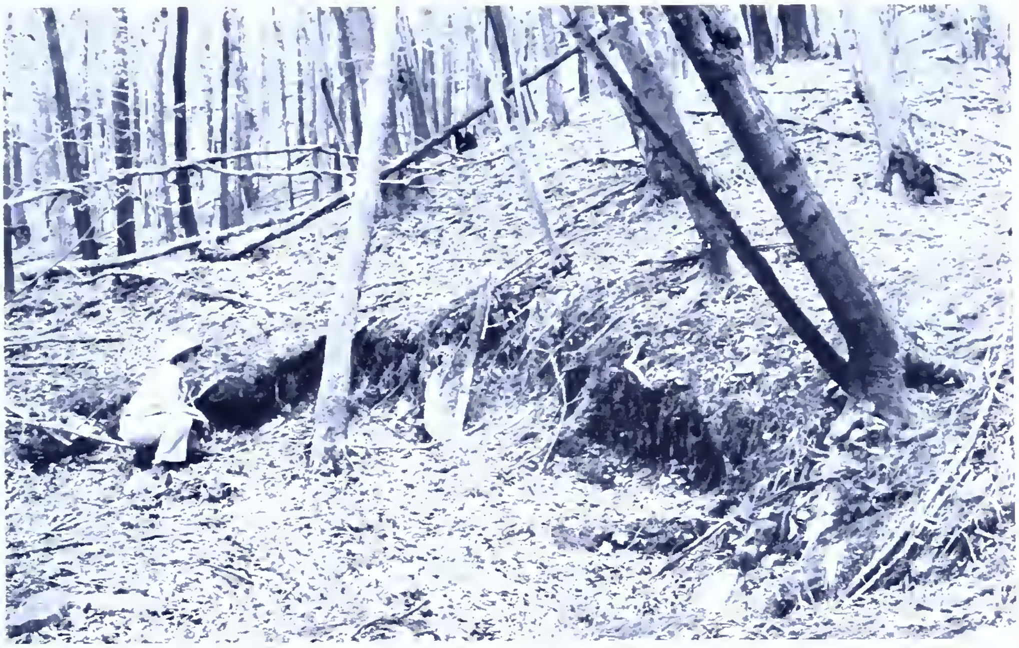
The main scarp of this landslide encompasses a zone of active slope movements, including several smaller landslides.

Viewed from a distance, the Kinzua landslide appears just like any other forested slope along the shore of the Allegheny Reservoir. But when walking through the area, one can see recent scarps, tilted trees, and fresh ground cracks.

The Kinzua landslide appears to be a reactivated, old landslide. The lower part of the slide mass is influenced by the fluctuating levels



North view to Kinzua landslide along shore of Allegheny Reservoir. Active slope movements are occurring in the forested slope in the center and left shoreline areas. Main scarp outline shown in color. May 1983.



Recent scarp and tilted trees on Kinzua landslide. May 1983.

of the Allegheny Reservoir. Due to periodic saturation of the toe caused by reservoir fluctuations, slope movements at the Kinzua landslide may be expected to continue, and possibly increase, in future years.

The bedrock at the Kinzua slide site is Upper Devonian Venango Formation. The landslide, however, involves clay-rich colluvium, presumably derived from siltstones, sandstones and shales of the overlying Mississippian and Devonian Shenango through Oswayo Formations. Thick deposits of colluvium accumulated on most lower slopes in this area during the Pleistocene Epoch. These are believed to be related to intense weathering associated with a harsh periglacial climate which affected areas near the ice margin.

THE BALD EAGLE FORMATION A SURPRISINGLY GOOD GAS RESERVOIR

by John A. Harper
Pennsylvania Geological Survey

One of the best kept "secrets" in Pennsylvania is the production of the Texaco-Marathon #1 Pennsylvania State Forest Tract 285 well in Grugan Township, Clinton County (Figure 1). This well, the second deepest ever drilled in Pennsylvania, gained a lot of attention while it was being drilled (see *Pennsylvania Geology,* v. 12, no. 5, 1981), and during the time that the operators searched for a potential producing horizon within the 19,365 feet of penetrated section. Although other companies have looked at the data on the well, its high production has not stimulated much apparent general interest or attention since being completed in December, 1982. Probably less than 10 calls in reference to this well have been made to the Survey's Oil and Gas Geology Division in Pittsburgh since that time. No information requests have come from Clinton County home owners, reporters, or Commonwealth officials. This general lack of attention is surprising to us because this particular well is presently one of the best natural gas producers in the state.

The original target of the Texaco-Marathon cooperative drilling effort was a faulted structure in the Cambro-Ordovician carbonates. The well bottomed in the Middle Cambrian Pleasant Hill Formation (Figure 2) without much promise of production from the deeper limestones and dolomites. Although several large shows of gas were encountered during drilling, all were in intervals shallower than the Middle Ordovician. These intervals were not initially investigated. When the original target zones were unsuccessfully tested and essentially dismissed as potential gas reservoirs, the companies decided to evaluate some of the shallower zones.

A reported large flow of gas at about 8,000 feet came from the Marcellus Formation, a black shale unit in the Middle Devonian Hamilton Group (Figure 2) that is notorious for its large initial flows of gas. These flows typically result from "bubbles" of gas which are created where the gas has leaked slowly from the rock into natural fractures (joints and faults) in the formation over the years. Most drillers are familiar with the Marcellus—regardless of the amount of gas first encountered in drilling, they all report that one can't produce economical quantities of gas from the shales. A driller therefore ignores the Marcellus, cases through it, and continues drilling to deeper, potentially more productive horizons. Such was the case with the Texaco-Marathon well.

The Late Ordovician Bald Eagle Formation at 13,000 feet (Figure 2) also had a show of gas, and it was large enough to attract attention. Although the operators did not submit specific information on the natural open flow from the formation on the official drilling report, the mud log on the well submitted to DER's Bureau of Forestry reported a large enough show such that the gas analyzer went off scale during logging. Also, the gas continued to be flared at the surface during subsequent drilling even though the well bore was heavily mudded (Gene Frund, personal communication). The approximate interval of this gas "show" (12,900 to 13,030 feet) was perforated and acidized. The subsequent flow of gas, gauged at 3,847 thousand cubic feet of gas per day (Mcfgpd), was large enough, however, that fracturing was deemed unnecessary. This open flow is not, in and of itself, particularly large; many shallower Paleozoic formations, such as the Upper Devonian sandstones, provide an occasional open flow of this volume, typically after hydraulic fracturing. Drillers report that even the tight Medina Group (Lower Silurian) of northwestern Pennsylvania commonly has after-treatment open flows of this size

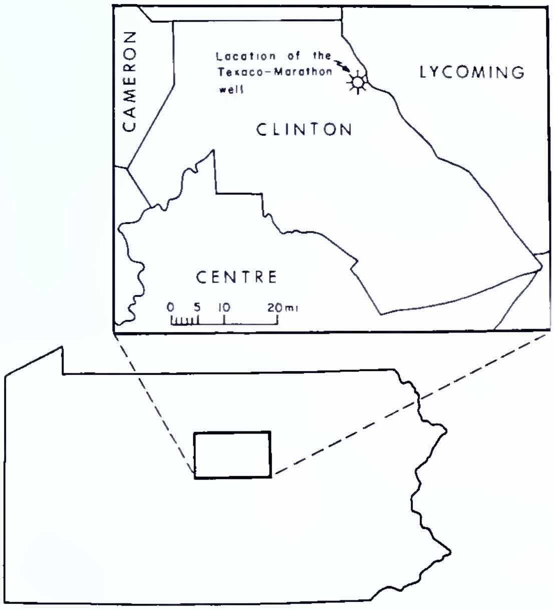


Figure 1. Location map of the Texaco-Marathon -1 Pennsylvania State Forest Tract -285 in Grugan Township, Clinton County.

in certain areas. Most of the wells in these formations, however, rarely go on to produce gas anywhere near the quantities gauged during the initial testing phase. The Texaco-Marathon well is rare in that it, unlike most wells, produced an astounding 307,966 Mcf between late August and December 31, 1983, averaging over 2,000 Mcf of daily production. During the first four months of 1984, the well produced an additional 249,776 Mcf, for an average daily production of 2,081 Mcfgpd, despite some shut-in time in January and April for well-testing purposes.

Because the Bald Eagle Formation is a new reservoir in Pennsylvania, not much is known about its geological characteristics in the subsurface. In outcrop, southeast of the Texaco-Marathon well, the Bald Eagle consists of about 750 feet of very fine- to coarse-grained or conglomeratic sandstones with some interbedded shales and siltsiltstones, especially near the upper and lower formational contacts (Faill and Wells, 1977). The sandstones, which are considered to be graywackes and subgraywackes, are typically medium to thick

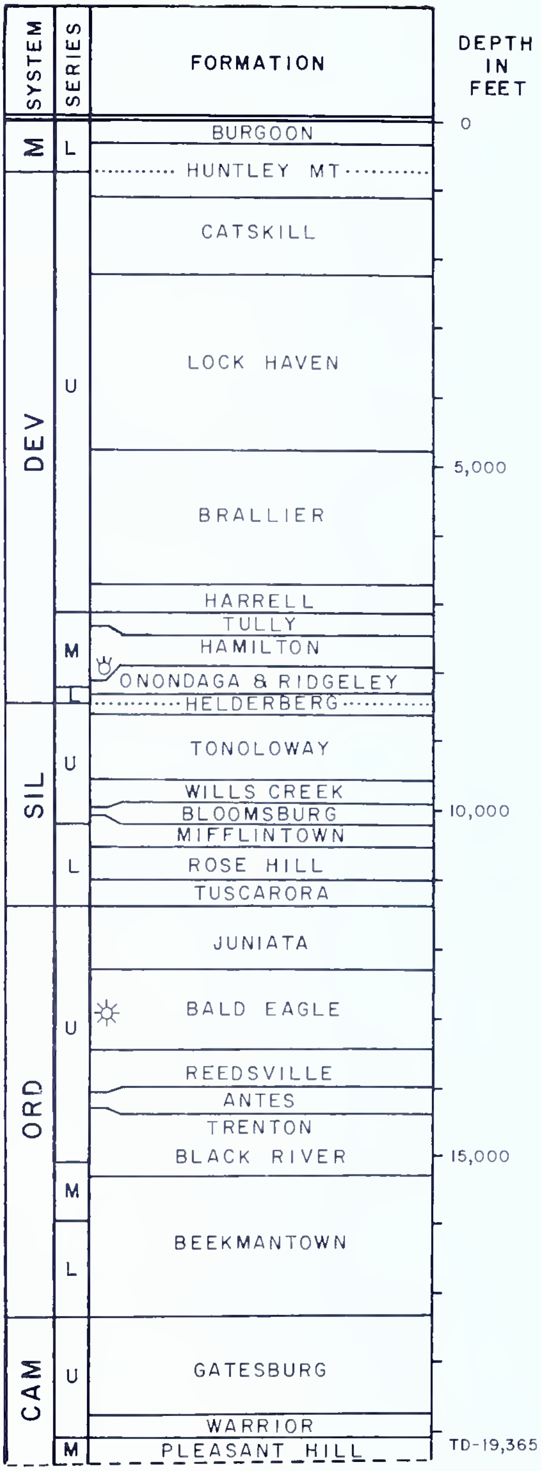


Figure 2. Stratigraphic column representing the formations and depths penetrated by the Texaco-Marathon well. The formation tops and bottoms shown were picked from submitted logs. Well symbols are used to indicate the show (Marcellus) and production (Bald Eagle) encountered in drilling the well.

bedded, often cross bedded. The conglomeratic beds contain assorted quartz pebbles and metamorphic rock frag-ments. The formation is a prominent ridge-former through- out the folded Appalachians of central Pennsylvania. Probably the best exposure of the Bald Eagle is in the spectacular "Big Cut" on Interstate 80 in Clinton County. At this locality the Bald Eagle can be seen grading into the red-colored Juniata Formation.

In the Clinton County well the Bald Eagle Formation consists of 1,215 feet of poorly sorted, calcareous fine- to medium-grained sandstone, siltstone, and shale. A preliminary lab report submitted by the well operators indicates the clastic fraction of the sandstones comprises quartz, feldspar, hornblende, chert, and pyrite. The grains are cemented with calcite and subsidiary dolomite. Authigenic clays (chlorite and mixed-layer illite-smectite) are also present. The rock is so tightly cemented with carbonate cements that intergranular porosity is extremely low, generally less than 2 percent (estimated) as determined by thin section analysis of the well cuttings. Because of the nature of the rock, with its tight matrix, the production of natural gas must be due to fractures in the formation. The high volumes of gas also suggest this.

The Texaco-Marathon well is a surprisingly good producer, and the Bald Eagle Formation is a surprisingly good reservoir. The few wells in central Pennsylvania that have penetrated the Bald Eagle section have had an occasional show of gas in the rocks, but never before has there been enough to attract the operator's attention. More drilling needs to be done in the area to establish whether the Clinton County well is a fluke or the Bald Eagle is "the Big One" that operators have been looking for since the 1950's. Thus far, only a small handful of companies have shown interest in the Texaco-Marathon well and its reservoir. Should one of these companies decide to risk the money necessary to drill another Bald Eagle well (estimated at about $5 million), and should such a well produce in the fashion of the Texaco-Marathon well, Pennsylvania could very well see a major explanatory and drilling boom develop in the north-central counties. Such a boom can only be of benefit to the citizens of the Commonwealth.

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A NIAGARAN (MID-SILURIAN) PATCH REEF NEAR ALLENWOOD, UNION COUNTY

by Jon D. Inners
Pennsylvania Geological Survey

Coral reefs in the geologic record range from great barrier reefs hundreds of feet high and many miles in extent down to small, patchy buildups several feet high and a few tens of feet in diameter. In order to technically qualify as reefs, however, these structures must possess two attributes: topographic relief and the ability to maintain growth within the wave zone (Heckel, 1974). In Pennsylvania and nearby states of the Appalachian region, fossil coral and related organic reefs are most commonly developed in carbonate rock sequences of the mid-Silurian (Lockport and Mifflintown Formations) and Middle Devonian (Onondaga Limestone). All of the mid-Silurian organic buildups appear to be small patch reefs that had limited relief above the sea floor. Within the fold belt of central Pennsylvania, the only such reefs previously known to outcrop occur in the Mifflintown Formation 1.5 miles southeast of Lock Haven, Clinton County (Cuffey and Davidheiser, 1979; Hoskins and others, 1983) and at Lakemont, Blair County (Swartz, 1935). Recent geologic mapping in Union County, 25 miles to the east of the relatively large reef at Lock Haven, has resulted in the discovery of a similar, albeit smaller, patch reef at approximately the same stratigraphic position near the village of Allenwood.

The newly found patch reef crops out in a small quarry on the south side of L.R. 627-59039 at the entrance to the White Deer Treatment Center, 1.3 miles west-southwest of Allenwood in Gregg Township (Lat. 41°06′09″N/Long. 76°55′27″W, Allenwood quadrangle; Figure 1). SINCE THE QUARRY IS LOCATED ON PROPERTY OF THE WHITE DEER TREATMENT CENTER, IT SHOULD BE VISITED ONLY FOR SCIENTIFIC PURPOSES. OBTAIN PERMISSION TO ENTER THE PROPERTY AT THE TREATMENT CENTER OFFICE.

Stratigraphically, the reef lies within the upper part ("McKenzie Limestone") of the Mifflintown Formation and is middle Niagaran (late Early Silurian or early Late Silurian) in age (Figure 2). The Mif-

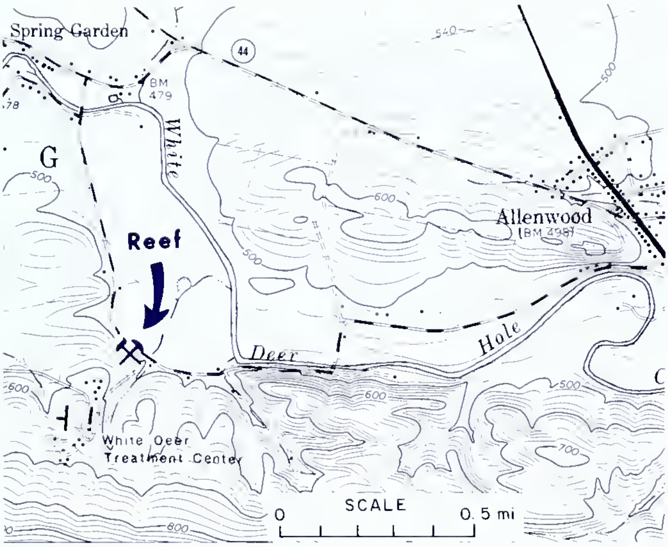

Figure 1. Location map.

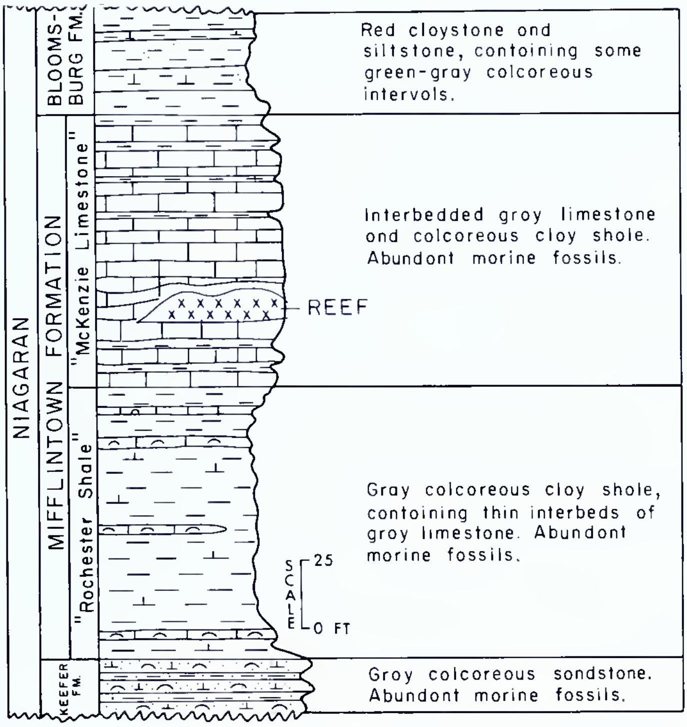
NIAGARAN
BLOOMSBURG FM.
MIFFLINTOWN FORMATION
"McKenzie Limestone"
"Rochester Shale"
KEEFER FM.
Red claystone and siltstone, containing some green-gray calcareous intervals.
Interbedded gray limestone and calcareous clay shale. Abundant marine fossils.
REEF
Gray calcareous clay shale, containing thin interbeds of gray limestone. Abundant marine fossils.
SCALE
25
0 FT
Gray calcareous sandstone. Abundant marine fossils.

Figure 2. Stratigraphic column of mid-Silurian rocks in the Allenwood area, showing position of patch reef.

flintown Formation in this area is approximately 200 feet thick, and the reef occurs about 125 feet above the base. Directly overlying and underlying the reef are thin to medium beds (mostly 2 to 12 inches thick) of medium dark gray, fossiliferous, silty limestone typical of the upper Mifflintown. The exposed portion of the patch reef is 5 feet thick, at least 15 feet long in a north-south direction, and at least 10 feet wide in an east-west direction. Except for these minimum dimensions, the exact size of the reef is unknown. No fragments of coralline rubble (so common on the quarry floor) were found on the hillslope to the west. However, a few fragments of coral occur in a shallow pit 50 feet east of the main quarry.

The reef consists of poorly bedded, medium dark gray, medium crystalline coralline limestone in irregular subspherical to ellipsoidal masses 2 to 3 feet in diameter (Figure 3). Subspherical to club-shaped coralla of a favositid ("honeycomb") coral constitute the overwhelming bulk of the reef rock. Judging from the small diameter (1 to 2 mm) of the individual corallites, this coral is probably *Favosites niagarensis* Hall (Figure 4). Scattered brachiopod valves and rare, solitary "horn" corals are the only other fossils that were observed within the reef mass.

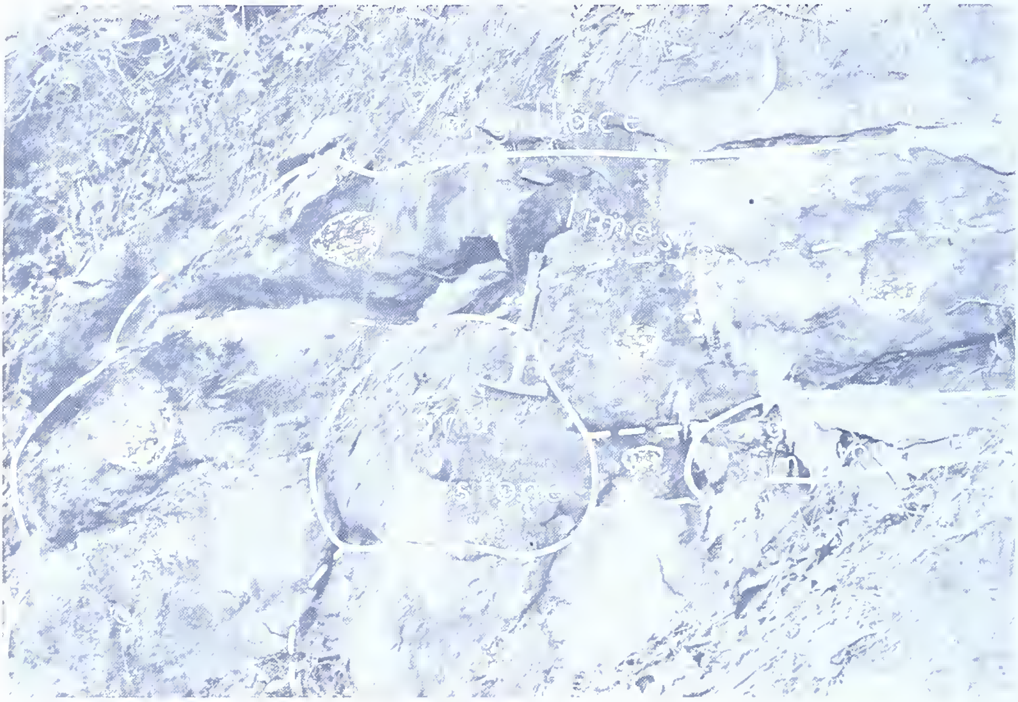

Figure 3. **Exposure of Allenwood reef on east side of quarry at Allenwood Treatment Center. Bedding dips about 25 degrees to the north. Hammer is 11 inches long.**

Because of poor exposure, direct evidence of wave action—such as the fragmental flanking beds that surround the Lock Haven reef (Cuffey and Davidheiser, 1979)—is lacking for the coralline buildup at Allenwood. The matrix of the reef rock is argillaceous, silty limestone that originated from the fine grained sediment trapped between the coral colonies. A pocket of medium crystalline, sandy

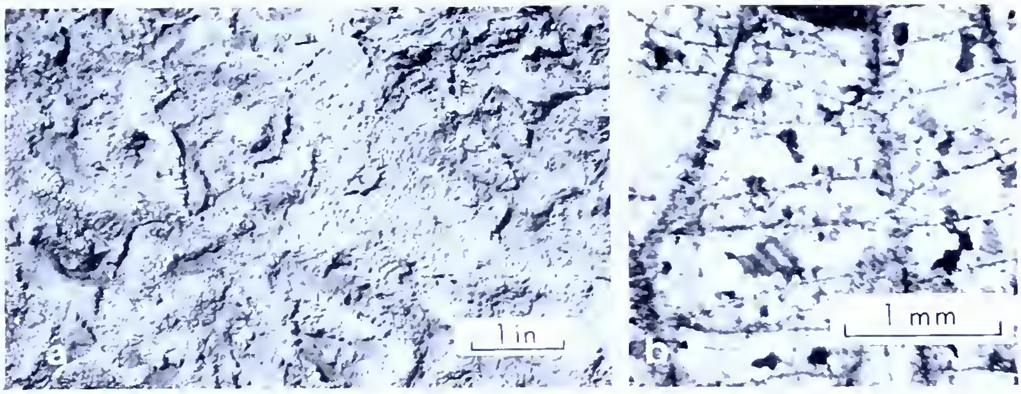

Figure 4. *Favosites niagarensis* Hall from Allenwood reef. a. Large block of coralline limestone, showing small size of corallites; b. Photomicrograph of thin section of favositid colony, showing corallites and tabulae (i.e., platforms which supported individual coral animals during growth of colony).

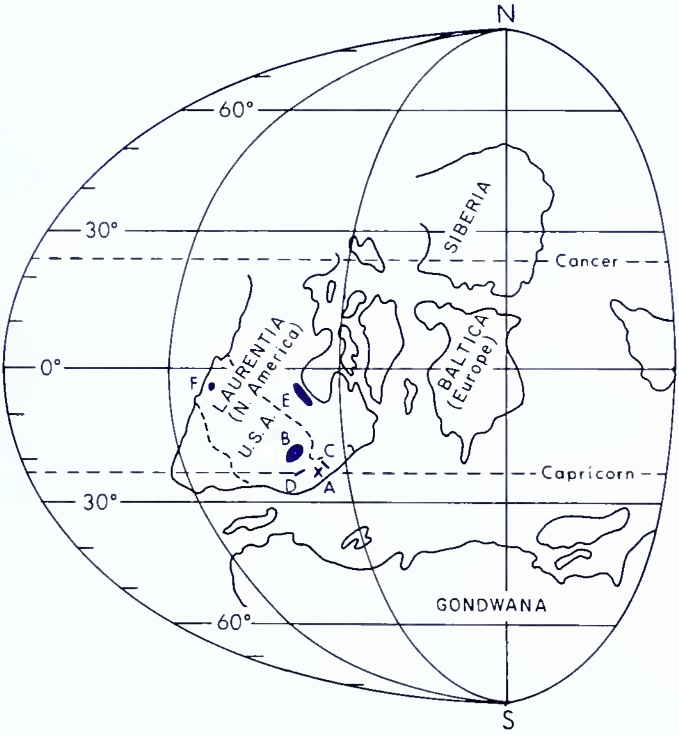

Figure 5. Niagaran (mid-Silurian) paleogeography. Note that most of North America was located within the tropic zone. Reef areas (color) are as follows: A. Allenwood, Lock Haven, and Lakemont reefs; B. Great Lakes region; C. western New York; D. West Virginia; E. Hudson Bay region; and F. central Nevada. (Base map from Scotese and others, 1979).

limestone, possibly formed from broken and wave-washed skeletal material, does occur within the main exposure on the east side of the quarry (see Figure 3). The overall evidence indicates, however, that the Allenwood reef formed in relatively quiet water barely above wave base, perhaps at a depth of several tens of feet.

The Niagaran Epoch witnessed the most extensive proliferation of reefs in North America during all of geologic time (Lowenstam, 1957). Significant reef tracts developed in the Great Lakes region, western New York, West Virginia, the Hudson Bay region, and central Nevada. The widespread occurrence of organic reefs in North America at this time was the result of (1) the expansion of shallow seas over much of the continent and (2) its geographic location within the Earth's tropic and subtropic climatic zones (Ziegler and others, 1979). As shown in Figure 5, the Allenwood, Lock Haven, and Lakemont reefs apparently formed on or very near the mid-Silurian Tropic of Capricorn (23 1/2°S Lat.). In the 420 million years since Niagaran time, the North American continent has moved at least 5,000 miles "northward" to its present position. As a result of this great plate-tectonic movement, the Allenwood reef and its many American contemporaries are now located well outside the climatic zones most hospitable to ancient and modern reef corals.

The author thanks Leslie T. Chubb for his assistance in describing and measuring the Allenwood reef. Dwight H. Rhodes, Williamsport, Pa., generously donated several excellent color photographs of the reef taken in the late summer of 1983.

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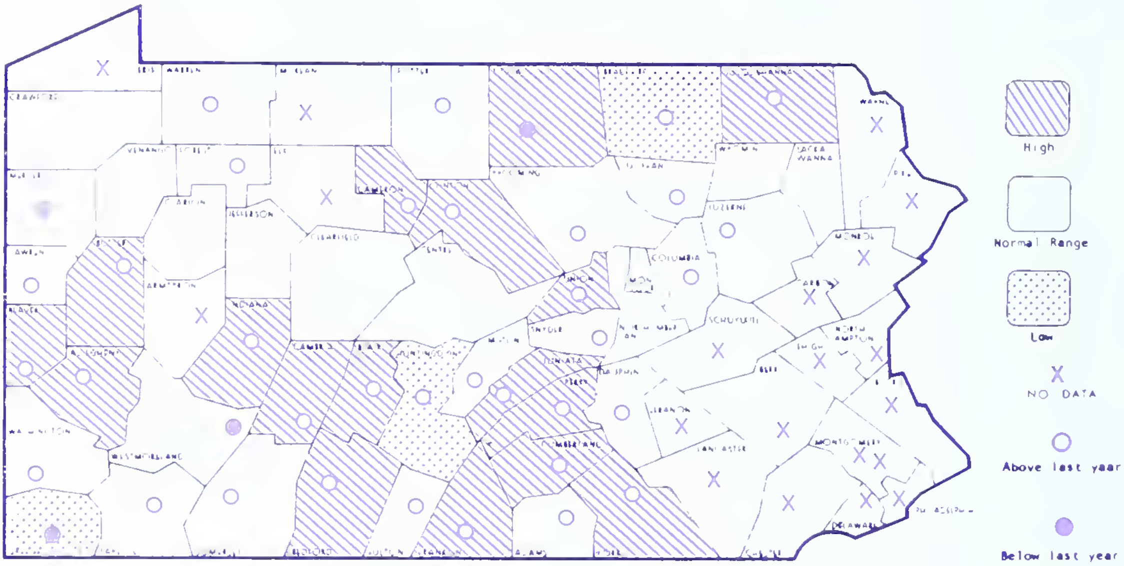

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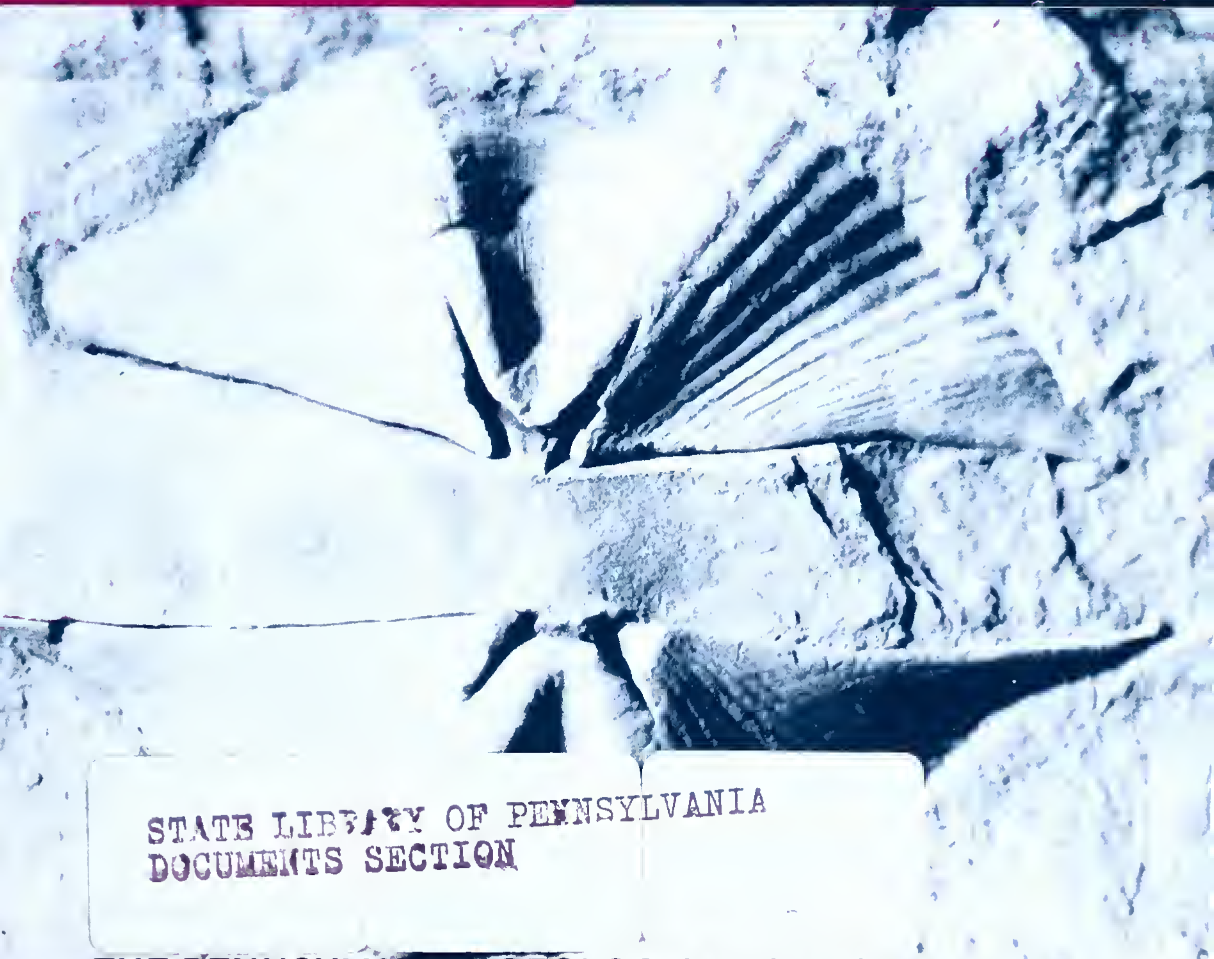

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ON THE COVER: Pair of *Orthospirifer mesastrialis* (Hall) (brachiopoda) collected by Willis A. Hall from the upper part of the Lock Haven Formation in West Burlington Township, Bradford County, Pennsylvania. These marine fossils from the Devonian Period are about 370 million years old.

PENNSYLVANIA GEOLOGY is published bimonthy by the Topographic and Geologic Survey, Pennsylvania Dept. of Environmental Resources, Harrisburg, Pennsylvania, 17120.

Editor, Arthur A. Socolow; Associate Editor, Donald M. Hoskins.

Articles may be reprinted from this magazine if credit is given to the Topographic and Geologic Survey.

VOL. 15, NO. 6 **DECEMBER, 1984**

FROM THE DESK OF THE STATE GEOLOGIST

HOW'S THE ROCK BUSINESS?

The other day a friend of mine stopped me on the street with the greeting "How's the rock business?" I could have answered "Rocky" and lost a friend, or "Booming" and conjure up exploding quarries. Instead, I gave him an honest answer, "Exciting."

How can inanimate, ancient, ordinary, widespread rocks be exciting? When their occurrence and physical properties hold the answer to such current issues as whether or not the proposed location for a hazardous waste disposal site is suitable and safe. Those "dull" rocks can become exciting if they are the type that results in sinkholes, such as the one which recently wiped out a state road in Lehigh County. Inanimate rocks can even become "animated" when the combination of their internal structure and erosion results in destructive and costly landslides such as we are encountering in parts of western Pennsylvania. The very unimposing rocks over which we daily walk and travel are commonly the source of the water supplies which sustain our lives and industries. And it is in the varied nature of Pennsylvania's rock formations where we shall find the answers to the question currently being posed, whether there is a suitable place to dispose of the low-level radioactive wastes originating in our hospitals and research laboratories. At one location it is the nature of the rocks which will determine if a proposed dam can be built on a foundation that will not settle, to hold water for a recreation lake.

These are just a few examples of how geology, "the rock business," enters into the daily lives and activities of each and every person. Perhaps they help to explain why a geologist, working with inanimate rocks in the field and laboratory, preparing maps and reports on the nature and distribution of the various rocks, can honestly answer, "The rock business is exciting."

Arthur A. Socolow

FLASH FLOOD ON WILLS CREEK

by J. Peter Wilshusen, Pennsylvania Geological Survey, and
John S. Pomeroy, U.S. Geological Survey

On August 13, 1984, Wills Creek, which has an average flow of 183 cubic feet per second at Hyndman (Figure 1), tore through its stream valley at an estimated 19,400 c.f.s., more than 100 times the average flow following a severe rain storm. Five people were killed and many homes destroyed; the state highway between Fairhope and Hyndman (Figure 2) on the border of Somerset and Bedford Counties was ripped from one side of the valley and a railroad track (Figure 3) left hanging like a tilted ladder, its bed washed away, on the other side. Verl Bittner, a 78 year old, lifetime resident of the area said it is the heaviest rain he has experienced. The rain gauge at his farm near the headwaters of Wills Creek measured 7.5 inches of precipitation between 9:00 a.m. and 1:40 p.m. on August 13. Another resident 3 miles southwest of Glencoe said, "There was no thunder or lightning and not much wind,

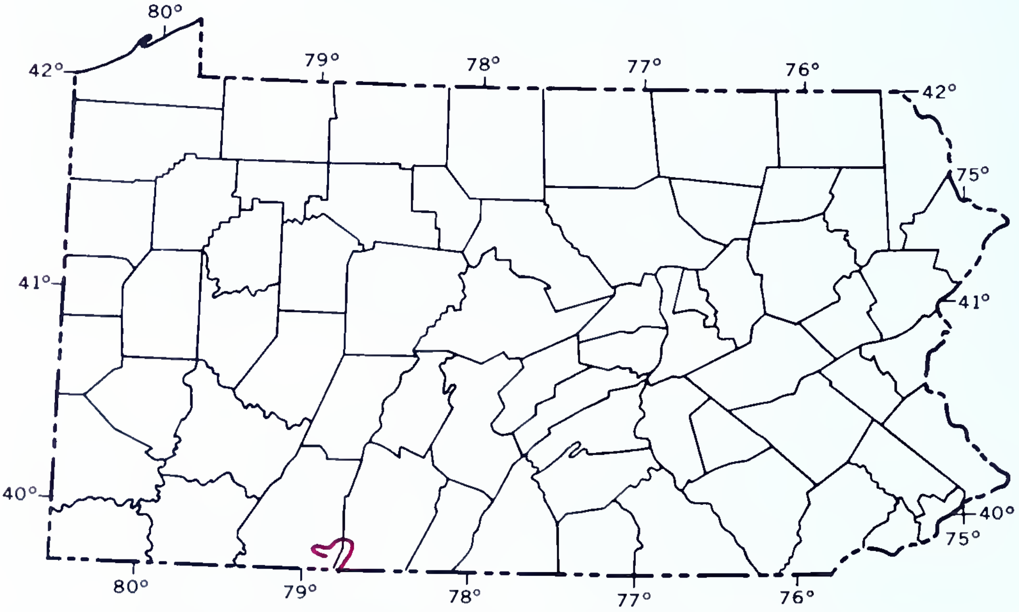

Figure 1. Location of Wills Creek in Bedford and Somerset Counties near Maryland border.

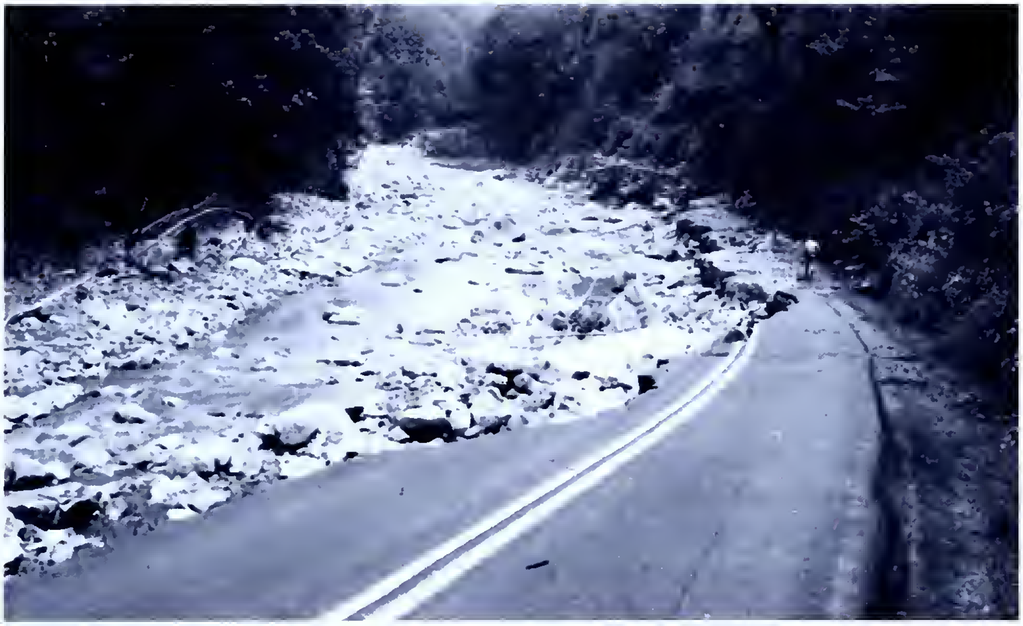

Figure 2. Looking downstream in Wills Creek Valley between Hyndman and Fairhope, Somerset County. An estimated flow of 19,400 c.f.s. (more than 100 times the average) scoured the streambed and did away with a newly reconstructed state highway along the right side of the stream.

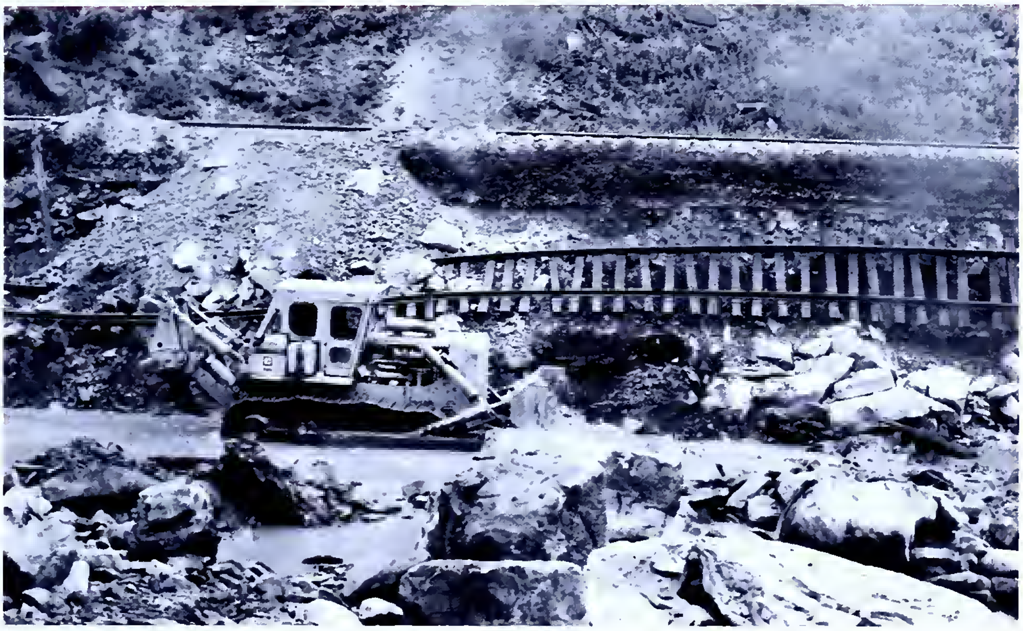

Figure 3. On the left side of Wills Creek, a short distance upstream from figure 1, heavy stream flow on August 13, 1984 undermined one of 2 tracks of the Baltimore and Ohio Railroad. A bulldozer clears channel obstructions.

just straight-down rain"; 6 inches of precipitation was recorded in her rain gauge. At Wittenberg, another 2 miles west, 5.5 inches of rain was recorded by the National Weather Service but, at Glencoe only 1.5 inches was recorded and not much more at Hyndman.

Precipitation records and unofficial reports indicate that this storm was confined to the upper reaches of Wills Creek in Somerset County, approximately 10 miles north of the Maryland border. It was characterized by a severe intensity acting over a small, sparsely populated area with an extremely high rate of stream erosion (Figure 4). The more populated downstream areas of Glencoe, Fairhope and Hyndman received very little precipitation but extremely heavy stream flow. Truck-sized boulders (Figure 5) which hadn't moved very much in 100 years were moved tens of feet or more downstream; smaller boulders and rock fragments were moved miles and sand and silt was swept rapidly into the Potamac River.

Flash flooding is not a rare phenomenon in western Pennsylvania. In recent years Johnstown in July 1977 (Pomeroy, 1980, 1982); East Brady during August 1980 (Pomeroy, in press); and the Oil City-Franklin area in June 1981 (Pomeroy and Popp, 1982) have experienced torrential rains resulting in minor to extensive storm-induced landsliding. A record maximum 24-hour rainfall in McKean County in July 1942 (Eisenlohr, 1952) amounted to 35 inches and caused extensive flood damage. Landsliding in that area was not extensive considering the record intensity of the storm according to John Hack and Charles Denny (U.S. Geological Survey) who visited McKean County after the 1941 storm and reported few major storm-induced mass movements.

A field examination of the Wills Creek basin after the recent storm provided some surprising information. In this area, which is transitional between the Appalachian Mountain section of the Valley and Ridge province and the Allegheny Mountain section of the Plateaus province, the hillsides are steep and the valleys narrow. The landscape, when hit by a heavy rain followed by high runoff, was expected to have had many landslides, but only one old slide was found and a second one reported but not verified.

The most intense rainfall for the August 13th storm fell on a terrain underlain by the Foreknobs and Scherr Formations of Devonian age. Interbedded sandstone, siltstone, and shale make up these stratigraphic units. From them are derived the most common soil types of the area, the Berks-Weikert and Leck Kill soils. Infiltration in these soils is moderate to moderately rapid and runoff is very rapid. The Wills Creek valley thus has slopes that are mantled with coarse, rocky soil with little clay and which are free draining. As a comparison, at Johnstown

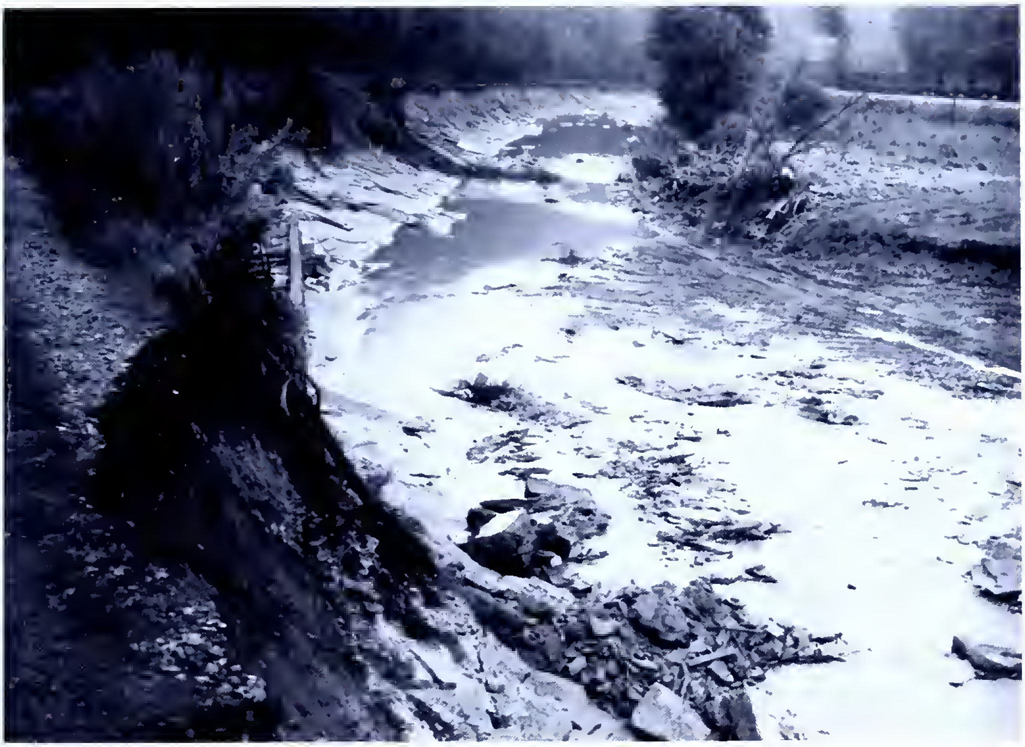

Figure 4. Wills Creek 1.2 miles downstream from Glencoe. In spite of severe channel scouring and bank erosion, there was no recorded landsliding along adjacent slopes. Most of the heavy precipitation was several miles upstream and valley sides here are well drained in stony soil with little clay content.

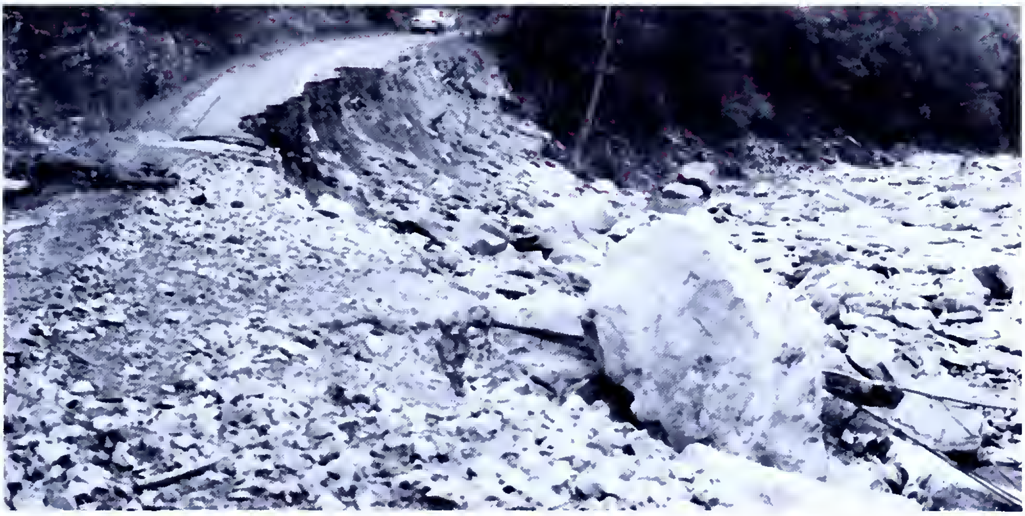

Figure 5. The storm water flow in Wills Creek was capable of moving large boulders and a tremendous bed load causing catastrophic changes to the stream channel.

the soil is not so coarse and there is more clay slowing drainage and allowing pore water pressure to build up and providing slide planes on which movement can take place. Johnstown received somewhat more than 11 inches of rain in 9 hours in 1977 causing several hundred landslides. The difference in landsliding appears to be in the nature of weathered rock and soil.

It's not difficult to be dramatic when reporting this event; newspaper accounts show photos that resemble tornado damage in the southeastern U.S. earlier this summer. The U.S.G.S. Water Resources Division estimated a statistical recurrence interval for the flood at Glencoe and at Hyndman to be greater than 100 years. As in these and most disasters, human response was immediate and effective. When we visited the area on August 29, the Soil Conservation Service was at work on the stream channel, the railroad was being rebuilt in Glencoe and the DER Bureau of Dams and Waterways Management was coordinating federal relief efforts.

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Berks Barite Study Completed

Reconnaissance float mapping of a 6 sq mi portion of the Bethel 7½′ quadrangle has resulted in the identification and description of 11 fetid barite occurrences in western Berks County. Host rock relationships and interpretations of paragenesis, age, and environments of deposition are offered in this study by S. W. Berkheiser, Jr. Mineral Resource Report 84, **Fetid Barite Occurrences, Western Berks County, Pennsylvania,** is available at the State Book Store, Rm G-56, South Office Building, Harrisburg, for $5.00 plus tax. If ordering by mail, enclose a check payable to the Commonwealth of Pennsylvania for $5.50 (plus $0.33 tax for PA residents) and send to the State Book Store, P. O. Box 1365, Harrisburg, PA 17105.

Fossils from Bradford County, Penna.

by Willis A. Hall

Although there are many marine fossils in Bradford County, few exposures containing fossils have been reported from the west central part of the county. While vacationing there in 1949 and the early 1950's the author located three sites (Figure 1) with good fossils in West Burlington Township about two miles south-southwest of Burlington. All of these locations were near the upper drainage area of Preacher Brook, a small stream in the southeastern portion of West Burlington Township that flows in a southeasterly direction until it joins the Towanda Creek near the Village of Franklindale.

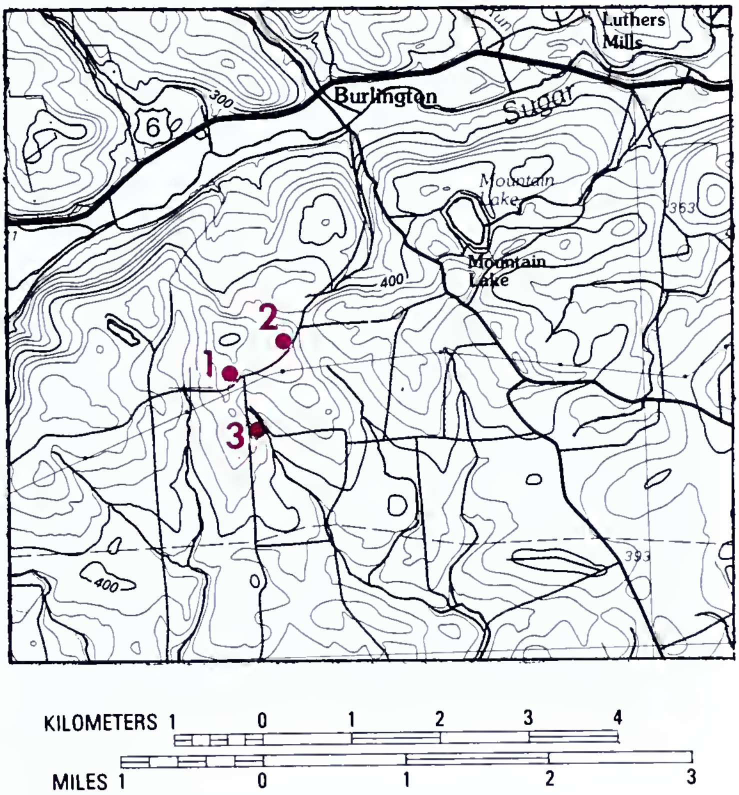

Figure 1. Location of collecting sites in West Burlington Township.

The exposures are very near the contact between the Lock Haven and Catskill Formations. There is a zone of transition between the marine Lock Haven and the fluvial-deltaic Catskill. Detailed stratigraphic studies in this part of Pennsylvania have not yet been carried out. The sites are just south of the LeRaysville syncline.

The fossil faunal assemblage at these sites is typical of the Upper Devonian. Most abundant are the brachiopod genera, *Cyrtospirifer, Orthospirifer,* and *Tylothyris.* Species of *Douvillina* and *Schuchertella* are also rather common. Only at site 2 were there an abundance of bivalves, probably representing two species of *Leptodesma.* Despite considerable faunal diversity, only the brachiopod *Spinatrypa hystrix* (Hall) was found at all three sites but is not common at any location. The fossils occur as molds and sediment-filled casts; in some instances there is considerable detail preserved.

Following are the locations of the exposures (Figure 1) and a list of fossils collected at each site:

Site 1 is located on the north side of the blacktop road about 0.6 mi. east of the former Fairview Church. This outcrop consists of gray, thinly-bedded shales and sandstones, some of which weather brown. Collecting was done in 1949 and 1950 and a blacktop road has since been put down over most of the exposure. The following fossils were collected there:

- Coelenterata
  - *Aulopora* sp.
- Brachiopoda
  - *Camarotoechia* sp.
  - *Chonetes* sp.
  - *Douvillina cayuta* (Hall)
  - *Nervostrophia nervosa* (Hall)
  - *Orthospirifer mesastrialis* (Hall) (cover photograph and Figure 2)
  - *Schuchertella chemungensis* (Conrad)
  - *Spinatrypa hystrix* (Hall)
  - *Tylothyris mesacostalis* (Hall)
- Bivalvia
  - *Eoschizodus chemungensis?* (Conrad)
  - *Leptodesma* sp.
- Gastropoda
  - *Holopea* sp. Hall 1849 or *Ptychospirina* sp. Pemer 1907
- Crinoidea
  - Columnals (undetermined species)

Site 2 is about 0.9 mi. east of Fairview Church along the north side of the same road as site 1. The following fossils were collected from gray to brown shales and sandstones at this exposure:

- Brachiopoda
  - *Cyrtospirifer disjunctus* (Sowerby)
  - *Douvillina cayuta* (Hall)
  - *Schizophoria* sp.
  - *Schuchertella chemungensis* (Conrad)
  - *Spinatrypa hystrix* (Hall)
  - *Tylothyris mesacostalis* Hall
- Bivalvia
  - *Leiopteria* sp., abundant
  - *Leptodesma* two species, abundant
- Cephalopoda
  - *Michelinoceras* sp.
- Crinoidea
  - Disarticulated columnals, rare
- Plantae
  - Stem segments, rare

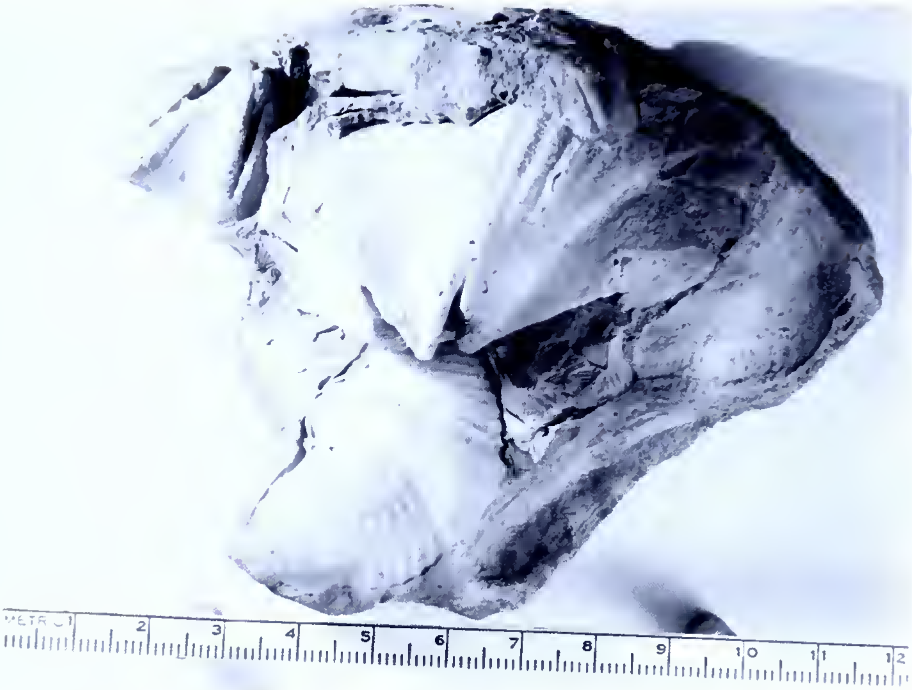

Figure 2. *Orthospirifer mesastrialis* (Hall) collected at Site 1 in West Burlington Township. Brachial and pedicle valves are preserved.

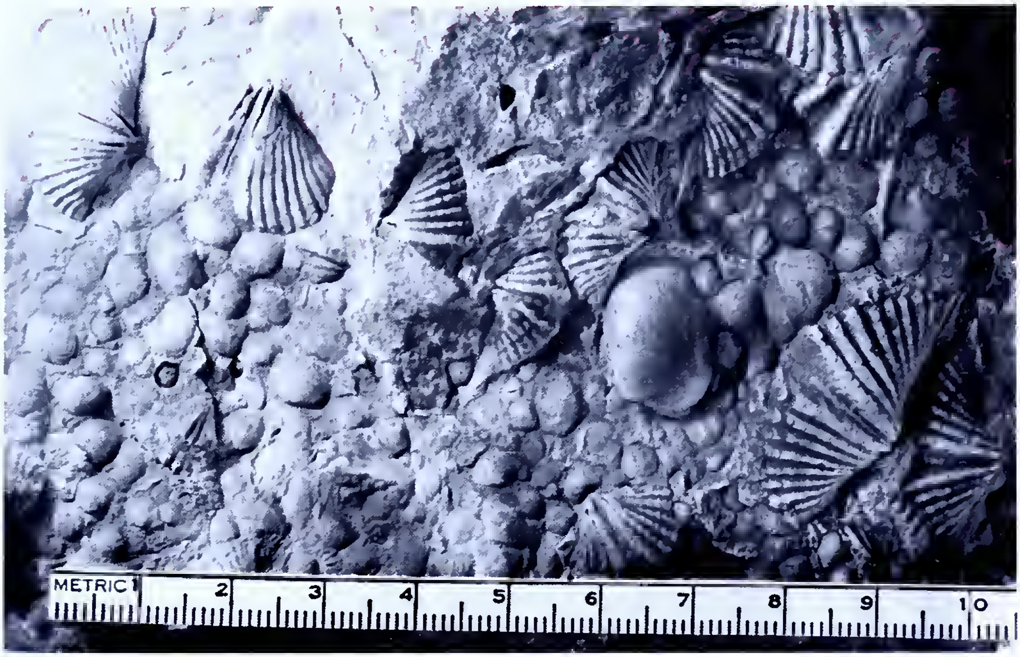

Figure 3. Slab collected at Site 3 bearing the fossil brachiopods *Tylothyris mesacostalis* Hall and *Chonetes* sp., along with the fossil clam, *Palaeoneilo* sp. (just right of center).

Site 3 is on the west side of Johnson Road, just above the point at which Preacher Brook crosses the highway. The owner of the land is William Jennings and permission should be obtained before collecting. The exposures comprise shales interbedded with gray to brown sandstones which are 1 to 3 in. thick. The following fossils were collected here:

- Brachiopoda
  - *Ambocoelia umbonata* (Conrad)
  - *Chonetes* sp. or *Dalmanella* sp. (small abundant specimens)
  - *Douvillina mucronata* (Conrad)
  - *Schuchertella chemungensis* (Conrad), common
  - *Spinatrypa hystrix* (Hall)
  - *Tylothyris mesacostalis* Hall, common
- Bivalvia
  - *Cypricardella* sp.
  - *Grammysia elliptica* Hall
  - *Leptodesma* sp.
  - *Lyriopecten* sp.
  - *Nucula* sp.
  - *Palaeoneilo* sp.
- Cephalopoda
  - *Michelinoceras*
- *Cricoconarida*
  - *Tentaculites* sp.
  - *Bryozoa*
  - *Batostomella* sp.
  - Undetermined genus-branching type
  - Undetermined genus-encrusting type
- Crinoidea

Promised Land and Raymond B. Winter Park Guides Now Available

The Bureau of Topographic and Geologic Survey has recently issued two new titles in the popular park guide series. "Promised Land State Park," authored by staff geologists William B. Sevon and Thomas M. Berg, describes the origin of the sedimentary rocks and glacial features of a portion of the Pocono Plateau in Pike County. "Raymond B. Winter State Park," authored by staff geologist Jon D. Inners, interprets the scenery, rock outcroppings and springs of a mountainous area in Union County. Both guides are richly illustrated with maps, photographs, and schematic diagrams.

Park Guides 18 and 19 are available at the respective state parks, or free upon request from the Bureau of Topographic and Geologic Survey, Box 2357, Harrisburg, PA 17120.

SUPPLY AND DEMAND FOR ABANDONED MINE RECLAMATION

by Bruce K. Ferguson
University of Georgia

The Blacklick Creek Watershed in Pennsylvania's Appalachian Plateau is one of the most devastated of old coal mining regions. Its 300 surface mines and 200 square miles of acid-bearing deep mines are continuously flushed by groundwater. One hundred eighty acid refuse banks lie exposed to rainfall. Every day 330,000 pounds of acidity, equivalent to 26,500 gallons of concentrated sulfuric acid, flow out of the watershed (Figure 1).

The devastation of Blacklick's old mines frequently lies directly in the path of the people who live, work, and play in the watershed. Many refuse piles are located in the centers of dense settlements. Designated fishing streams are cut short where they join streams polluted with acid. Many public parks, historic sites, and natural sites are adjacent to disturbed land and polluted water.

In 1980, the U.S. Bureau of Mines began to explore Blacklick's potential for mine reclamation on a watershed-wide basis (Ferguson, in press A, in press B). Such a large-scale effort could involve potentially hundreds of land and water reclamation projects, stretching decades into the future. Initial estimates of the cost of reclaiming all the mining features in the watershed ranged from two to four billion dollars. It was clear that priorities had to be established and choices had to be made.

The framework for setting Blacklick's priorities was based on the premise that, the worse the conditions of the land and water, and the more those conditions interfered with the lives of people, the more was reclamation needed. Consequently, the planning procedure sought to establish reclamation objectives by comparing the public "demand" for reclamation with the "supply" of mining sites to be reclaimed. The priority for reclamation was conceived to be highest where both "demand" and "supply" were greatest. In such places, the greatest mining disturbances intruded most directly on the values of people.

Demand for Reclamation to be Done

The watershed has a population of 70,000. As in most of the northeastern United States, the denser old agricultural and mining set-

Figure 1. Relics of abandoned mines adjacent to the village of Revloc, on the South Branch of Blacklick Creek. Piles are mostly coal refuse, some strip mine overburden; much placed here over a century ago. Smoke issuing from one on the right. The pH of the stream here is about 4. Sliding of material into the stream has dammed up the water, forming the acid lake in the background. Note the absence of vegetation.

tlements are declining. Some low-density development is occurring in the expansive rural areas.

The locations of roads, settlements, and natural, historic and recreational sites are where people live, work, play, learn and travel every day. These are the places where mining disturbances may intrude upon their lives. Those locations and the nearby areas that were visible from them were rated as to the strength with which the people evaluated their local environments. Visitors to natural, historic and recreational sites presumably evaluated those environments more strongly than residents and travelers evaluated ordinary settlements and roads.

The region's landforms provide an ubiquitous backdrop against which the effects of reclamation may be perceived. The distinctiveness of that background creates a foil which may magnify the perceived impacts of land and water disturbances. Hence the types of landforms (mountain, valley, gorge, etc.) were rated as to perceptual distinctiveness.

Overall land use resource values were assigned by comparing background distinctiveness with sensitivity of observed areas. The highest values were along streams and around natural, historic and recreational sites. The lowest values predominated where there were few or no observer positions.

Land Reclamation

The above-ground mining features were refuse piles and strip mines. The degrees of land disturbance resulting from those features were evaluated according to the extents of regrading and revegetation necessary to return the features to near-natural conditions.

All of the Watershed's 180 refuse piles were placed in the highest disturbance class. They were uniformly bare of vegetation, dull black in color, and lying in jumbled heaps. The strip mines varied greatly in their grading and vegetation and were placed in a correspondingly wide range of disturbance classes.

The priorities for land reclamation shown in Figure 2 were determined by comparing "supply"—the degrees of land disturbance—and "demand"—the values of the land use resource. A sequence of land reclamation projects would begin among the sites with the highest priority and work directly down the path of declining priorities.

Water Reclamation

The water quality effect of mining were reflected in the streams' acid load. By tracing the acid load upstream to its origins, we identified more than 90 pollution sources each of which generated at least 100 pounds of acid per day.

In terms of area, deep mines represented the largest acid pollution sources. Some of the deep mines were among the most productive acid sources. Many refuse piles competed with the deep mines in terms of acid production per source, although they were very small in terms of area.

Unlike land disturbances, water pollution sources are interconnected by the stream system. Consequently, we subtracted the amount of upstream pollution from the amount of acid produced by each source, as an index of the relative impact of the added pollution. This indicated the "supply" of damage to be abated.

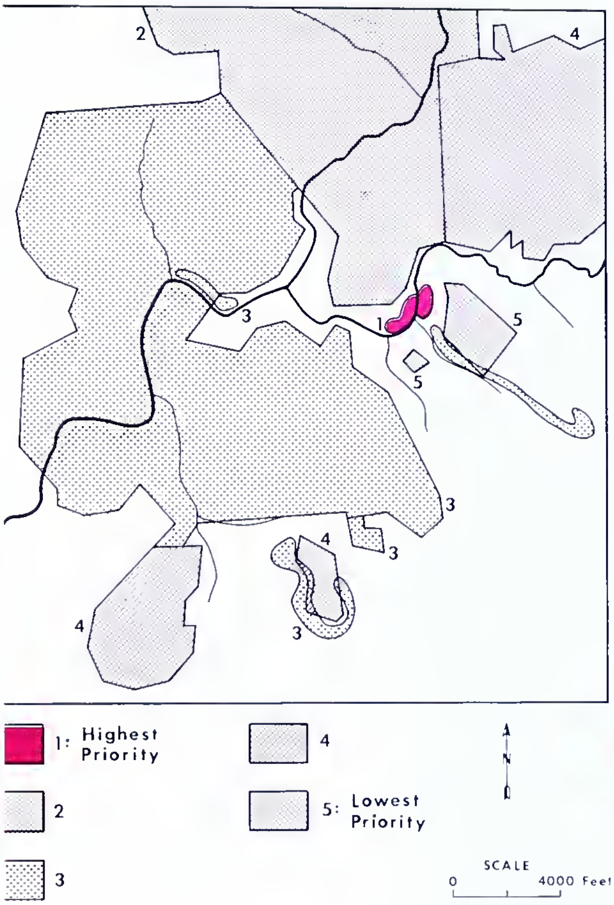

Figure 2. Part of Blacklick's map of land reclamation objectives.

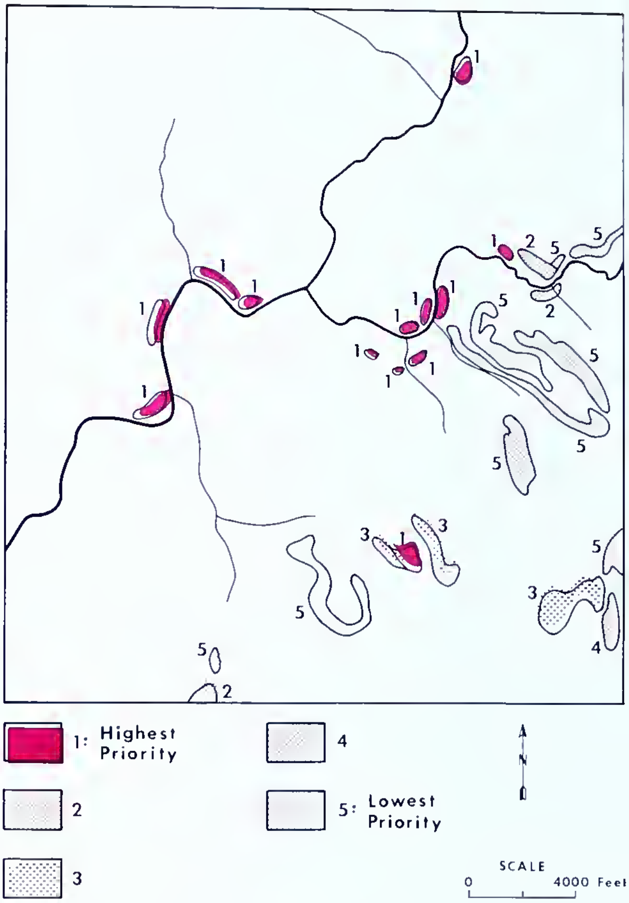

Figure 3. Part of Blacklick's map of water reclamation objectives.

The value of each stream reach came from the fact that it flowed through some combination of land use resource zones. The value level and length of the reach affected by each pollution source were combined numerically. The resulting index of value was assigned to the responsible pollution source. This indicated the "demand" for improvement to be made.

On the map of water reclamation objectives (Figure 3), in the highest category of priority were eight refuse banks and deep mines located throughout the watershed.

A sequence of water reclamation projects would start at a site with very high priority. The successful completion of each project would tend to cause an increase in the relative priorities of nearby pollution sources, due to reduction of "competing" pollution in the stream system.

Conclusion

The maps of Blacklick's reclamation objectives can define the locations, priorities and phasing of reclamation projects over a long period of time. Reclamation projects conceived in concert with both "supply" and "demand" can have strong leverage for creating large and rapid benefit from the application of limited reclamation funds.

One specific conclusion that could be drawn from the maps concerned a proposal for incinerating refuse pile material, the production of energy from the heat to produce income, and the use of the incinerated ash to fill deep mines. Several combinations of adjacent or overlapping high-priority refuse piles and deep mines can be seen on the water reclamation objectives maps. Those locations immediately stand out as likely prospects for the implementation of the concept.

Another specific conclusion concerned an early proposal to do land reclamation without losing major opportunities for water reclamation. It was in an appropriate area for that concept, since there were large amounts of disturbed land but not much acid drainage. However, the map of land reclamation objectives showed those disturbed lands to be out of the way of people, and so of low reclamation priorities.

A third conclusion concerned the presence of some refuse piles and strip mines in the higher priorities for both land and water reclamation. The reclamation of such features could achieve both kinds of improvement at once.

The design of any specific reclamation projects would depend on what types of technologies were proposed. Many types of technologies may be considered in the course of a long-term program. Technologies discussed during the Blacklick planning included development of industrial parks; sites for second homes and landfills; deep mine sealing; strip mine regrading and revegetation; "Incineration-Income-Injection"; and in-stream pollution controls such as water treatment plants and construction of artificial wetlands. Regardless of what technology is proposed, its application to the watershed should be conceived, and its reclamation benefits tested, against the background of objectives maps as described in this paper.

References

Ferguson, B. K. (in press), A. *Criteria for abandoned mine reclamation: regional planning to develop project guidelines in the Blacklick Creek Watershed, Pennsylvania*. U.S. Bureau of Mines.

Ferguson, B. K. (in press), B. *Priorities for abandoned mine reclamation in the Blacklick Creek Watershed, Pennsylvania*. U.S. Bureau of Mines.

Pennsylvania's 1983 Oil and Gas Developments

Did you know that in 1983 Pennsylvania produced 4,490,672 barrels of oil and 118,372 million cubic feet of gas? This production had a total value of over $480 million to the oil and gas industry. Are you aware that recoverable reserves totaling 581,193 million cubic feet of gas were stored in Pennsylvania's storage fields in 1983 (Pennsylvania ranks third in the nation in total reservoir storage capacity behind Michigan and Illinois)? Have you been informed that a 5,500 foot deep gas well in the Medina Group sandstones of northwestern Pennsylvania cost operators an average of $30 per foot? These and other facts concerning Pennsylvania's oil and gas industry are now available in the newly released *Oil and Gas Developments in Pennsylvania in 1983,* issued by DER's Bureau of Topographic and Geologic Survey.

This 87-page annual report, by John Harper, Chief of the Survey's Oil and Gas Geology Division in Pittsburgh, contains much useful information about well completions, production, reserves, gas storage, prices, enhanced oil recovery, exploration and development, activities on state lands, and projects in progress at the Oil and Gas Geology Division. The report has numerous graphs, tables, and illustrations supporting the text.

Oil- and gas-well drilling, gas production, and gas reserves declined over the previous year, but oil production was up by 5 percent over 1982, and oil reserves increased a whopping 43 percent. Although reserves were added in all of Pennsylvania's districts, the biggest single increase was due to a re-evaluation of the historic Bradford field of McKean County.

During 1983, Pennsylvania's oil and gas operators reported 2,540 well completions. This was a 40 percent decrease in total wells from the record high of 1982. The most active counties for oil drilling were Venango, Warren, Forest, and McKean; the most active counties for gas drilling were Erie, Indiana, Jefferson, Warren, and Crawford.

Progress Report 197, *Oil and Gas Developments in Pennsylvania in 1983,* is available from the State Book Store, P.O. Box 1365, Harrisburg, PA 17105 for $1.65 (plus 10¢ tax for Pennsylvania residents). Checks made payable to the Commonwealth of Pennsylvania must accompany the order.

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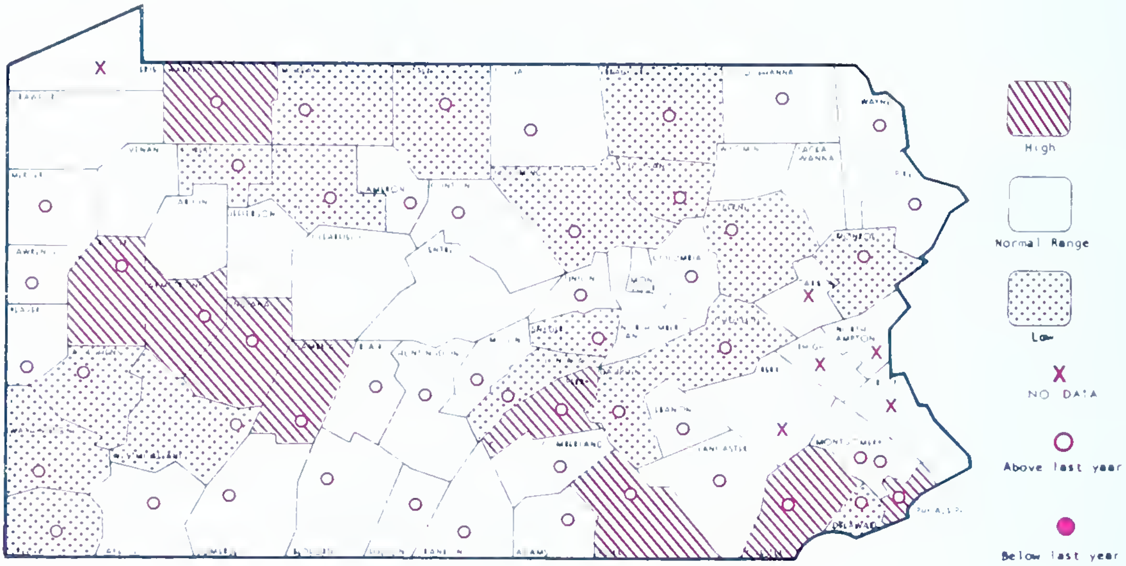

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